FIRST REPORT

OF THE

SECRETARY OF AGRICULTURE.

1889.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

[PUBLIC RESOLUTION—No. 1.]

Joint resolution to print the Agricultural report for eighteen hundred and eighty-nine.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the Annual Report of the Secretary of Agriculture for the year eighteen hundred and eighty-nine; seventy-five thousand copies for the use of the members of the Senate; three hundred thousand copies for the use of the members of the House of Representatives, and twenty-five thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture, and the copy for the illustrations of said report shall be placed in the hands of the Public Printer not later than the thirtieth day of December eighteen hundred and eighty-nine, and the copy of the text not later than the fifteenth day of February, eighteen hundred and ninety.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of printing and binding said report.

Approved, December 19, 1889.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT

OF THE

SECRETARY OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 26, 1889.

To the PRESIDENT:

I have the honor to respectfully submit my first annual report as Secretary of Agriculture, and the first report issued under the newly constituted Department of Agriculture.

I assumed the duties of my office March 7, 1889, or twenty-six days after the approval of the law creating an Executive Department of what had theretofore been a Bureau, in executive sense, of the Government. The Department had reached an important epoch in its history. For years there had been a demand on the part of a large majority of the farmers of the country that that Department at the seat of government which was organized to represent their interests should be clothed with the same dignity and power that other Executive Departments had, and that it should have its influence in national affairs and be recognized in the councils of the nation.

It is not necessary for me to dwell at this time upon the past growth of this institution; how there have been assigned to it from time to time additional duties and power until now, when it comes forward as a completed wing of the executive branch of the Government, entitled to its full share of attention and protection, and needing at this time careful and intelligent effort in order that the foundation now ready to be laid shall be the commencement of a great and lasting Department, well fitted to extend its usefulness over a great agricultural domain. I deemed it my first duty, therefore, to give particular attention to such a re-adjustment of the current affairs of the Department as should make it better conform to its new relations under the law, and then to give careful thought to the formulation of plans for a thorough and complete reorganization of the new Department. I am not unmindful of the difficulties in the duties which have fallen

to me in this regard, nor do I think that I shall overstate those to which I shall here refer.

At the very beginning I was disappointed to find that the appropriations made for the operations of the Department for the current fiscal year were those based upon the old organization of the Department, and that no provision had been made for a single anticipated want of the Department in its new field of duty. Therefore my first efforts had to be restricted to the study and formulation of plans for reorganization; to the systematizing of the records of the Department; to the consolidation, so far as possible under one head, of work of one character but being conducted in different divisions of the Department; to the formulation of a better system for the faithful accounting of public property, and in general the application of business-like principles throughout the Department. I have performed this duty while awaiting the meeting of Congress, when its attention might be called to the condition of affairs to which I have alluded, and to the urgent need of immediate attention.

Again, I found that during the growth of the Department to which I have heretofore referred, no adequate provision had been made in the mean time for additional space to meet its rapidly increasing needs. The building it occupies was erected many years ago, and at a time when the future of the Department was problematical, and when its needs could not be anticipated. I found clerks crowded into rooms and subject to discomforts and inconveniences. I have found two branches of two distinct divisions crowded into one small room; records and books lying about upon tables and chairs for want of sufficient wall space to accommodate cases for their proper care and preservation; the chemical laboratory crowded into a damp, illy ventilated, and wholly unsuitable basement, originally intended no doubt for storage purposes, and its work in certain investigations restricted because of the offensive fumes from such analyses, and because of the dangers to human life and limb from explosions of gases and other causes; and, in a word, there was a complete want of that systematic and orderly conduct of the public business which ought to obtain in every well-conducted office.

REORGANIZATION

The immediate wants of the Department then, are, first, appropriations which must be made to meet the obligations of the Department to the country, which I deem urgent; and, second, a laboratory to be erected on the Department grounds, suitable for the purposes of important investigations which can not now be undertaken. This building should be ready for occupancy at the earliest practicable day. To it I could remove certain scientific divisions and thus get much needed relief in the main building. In the mean time, I respectfully and urgently recommend that there be given me authority to rent

some suitable building in this city to which divisions of the Department can be removed in order to temporarily relieve the necessity which confronts me.

Pending this necessary legislation I propose to complete plans, already formulated, for a reorganization of this Department, and a portion of which has been anticipated in my estimates for the coming fiscal year. These estimates show a considerable increase over those of last year. Deducting the $630,000 appropriated directly to the experiment stations of the country, and there is left for the Department's needs $1,359,000, an amount which should not be measured by what is in the past, but rather by what a great agricultural country should pay at this time toward sustaining, protecting, and promoting a calling which lies at the foundation of its prosperity and power.

In other civilized countries, and especially in the newer countries of the world, among whom we are finding our most vigorous competitors, work analogous to that covered by this Department is prosecuted with a liberality and energy which, while it commands our respect, should not fail to serve as a warning that we ourselves must do our full duty in this matter if we expect to maintain our proud pre-eminence as the leading agricultural country of the world. Our sister republics in Central and Southern America and the Empire of Brazil have with few exceptions been devoting their best efforts, aided by liberal appropriations, to the application of science to agriculture, and this with marked success. To the north of us Canada, which has for years possessed a department of agriculture, has been working with creditable zeal on the same lines, and the same may be said of all the British colonies.

Turning our attention to the older countries of the world, we find a British department of agriculture recently established, with a million and a half dollars annual appropriation at its command, while the same power combines Anglo-Saxon energy with the paternal government of the Latin races in its efforts to develop in India and in Egypt agricultural products commensurate to their teeming population and soil fertility. Germany annually expends $2,850,000 for the same purposes. Brazil appropriated in 1885–'86 more than twenty millions of dollars for her agriculture, commerce, and public works. Russia more than fourteen millions for agriculture and mines for the same period. France appropriated in 1886 more than eight million dollars for her agriculture alone, and Austria more than four millions during the same year.

It is my desire to organize the Department upon even a broader plane than these and other countries have established. To do so will require time and patience and that share of encouragement and support which I trust Congress will give to the Department and to the efforts of its officers.

ASSISTANT SECRETARY.

Among the features of the new law applying to this Department was a provision for an Assistant Secretary of Agriculture. Thanks to the wisdom of your choice in the selection for this position of a gentleman combining a large experience in public affairs with a thorough knowledge of scientific agriculture and trained executive ability, I have been enabled to meet a want that has long existed in the Department, and to take one of the most important steps toward its reorganization. I have divided the Department into two grand divisions, one embracing all those divisions, branches, and sections which involve more particularly administrative and executive features, and which have been retained under my personal supervision, and the other embracing those divisions which are engaged purely in scientific investigations, which have been assigned to the office of Assistant Secretary. This plan of reorganization has been in operation for some months, and its advantage in the administration of the Department's affairs is plainly evident.

PUBLICATIONS.

One of the first conclusions forced upon me, after a careful review of the valuable work of the several divisions of the Department in its application to the economy of agriculture, was the absolute necessity for prompt and effectual means of reaching the class the Department was primarily designed to serve, *i. e.*, the farmers. The very essence of the duties devolving on this Department of the Government is that its results shall be promptly made available to the public by a comprehensive scheme of publication. Time and expense, ability and experience, lavished on the work of this Department can have no practical results unless we can lay their conclusions promptly before the people who need them.

The frequent issue of special bulletins from the various divisions relating to the work undertaken by them, instead of awaiting the issue of the annual report, already too bulky for the purpose for which I conceive it to be designed, meets with my unqualified approval, and I propose to greatly extend this practical method of intercommunication between the Department and its constituents. To reach the farmers of the country effectually, however, even more is needed than the issue of frequent bulletins in editions of 5,000 or 10,000 copies. Many of these are essentially and unavoidably scientific and the careful record of scientific investigations by scientific men, the value of whose conclusions must necessarily bear the scrutiny of scientific investigators the world over. The elimination of all scientific terms and language from such reports is impossible, while at the same time it is feasible and essential that all practical conclusions arrived at, as the result of scientific observation or investigation,

must be so expressed as to be readily understood by all ordinarily intelligent people of average education.

Again, as to the number of copies required and the methods adopted for their circulation, it is clearly impossible to reach every farmer on the nearly 5,000,000 farms of the United States with all the bulletins emanating from this Department, nor is it desirable that every bulletin should reach every farmer. Farming is becoming more and more differentiated, not only into main divisions naturally created by limitations as to climate and soil, but into minor divisions or specialties due to the larger experience, the higher degree of skill required in the present day to enable a farmer to prosecute his work successfully, and to which but few men can attain in more than one or two specialties or branches of farming. Herein we find another strong argument for the diffusion of the results of our Department work in the form of special bulletins, convenient in form, promptly printed, and easily distributed.

The points to be covered in this direction may then be thus briefly summarized:

(1) Frequent publication of the results of scientific work in the various divisions, in the form of special bulletins.

(2) The observance, as far as practicable, of such language as will render the contents of each bulletin available to the average layman.

(3) A method of distribution which will secure the circulation of the Department bulletins among those who will make practical use of them.

(4) The widespread publication of the practical conclusions of the scientific observations or investigations undertaken in the various divisions, in a brief form and plain terms and on a scale so extensive as to practically reach all the farmers of this country.

To accomplish these four main objects I last July established a division in charge of a gentleman having special experience and qualifications for such work, and who will have general supervision of all the publications issued by the Department.

With a view to carrying out as far as possible the fourth proposition, upon which I lay particular stress, the plan adopted, and, as results so far show, with gratifying success, has been to prepare advance sheets of every bulletin or other publication about to be issued, such advance sheets comprising a brief synopsis of the work recorded in the bulletin and giving the conclusions arrived at which may serve as practical suggestions to the farmers. These advance sheets are furnished to the press associations, to all agricultural and many other weekly papers, to agricultural writers, and any journalists and editors applying for them. In this way, during the fifteen weeks ending October 31 no less than eighteen such synopses or résumés were

distributed as above. It is a pleasure to record the fact that the agcultural papers generally and the press as a whole have shown a most commendable disposition to co-operate with the Department in its efforts to keep the farmers informed as to all that may be of practical service to them. In some cases a careful note kept of the newspapers publishing such advance sheets, apart from those covered by the press associations, indicate an aggregate circulation of over 1,000,000 copies.

A moment's consideration will show the value of a plan by which the benefits of a bulletin reaching 5,000 or 10,000 copies, and that by means of a circulation dragging along through many months, are communicated immediately to a circle of readers aggregating over three million persons, or nearly one-sixth of our entire adult farming population. Indeed this plan virtually covers the entire field, for the farmer who does not read some paper devoted to his calling is practically beyond the reach of intelligent effort on his behalf. It moreover invites application for special bulletins in advance of their publication by interested parties, an important consideration, for in the giving of valuable information "he gives twice who gives promptly."

The work of the new division in the review of the bulletins and other publications issued by the Department is sufficiently indicated by the list of such publications forming a part of this report.

The work now engaging the attention of the several divisions of this Department is progressing satisfactorily, and I will here present for your information a résumé of what each is doing in its especial sphere. In conjunction therewith I also lay before you an outline of my plans for extending the work of these divisions, increasing their facility and enlarging their usefulness, plans which I consider essential to the successful prosecution of work which it is the duty of this Department to undertake.

DIVISION OF STATISTICS.

This branch of the Department service, relating to national resources and their development, to rural production, and to distribution and consumption, is in my judgment one of the utmost importance. To aid in the collection of agricultural statistics there are over 11,000 volunteer correspondents, and a paid corps of agents in as many States as the limited appropriation allows the Department to maintain. These conduct a parallel investigation, by States, for verification and extension of the data communicated by the regular corps. What the system most lacks at present is the ability to maintain a paid statistical agent in every State. I would therefore urge the necessity of restoring, or even increasing, the original appropriation for collection of statistics, which has been reduced during the past four years, to render it possible to carry out the requirement

for employing State agents for local investigations in every State, and for the collection of such specific statistics as can not be obtained through the voluntary effort of our public-spirited farmers.

The office receives current official statistics from every part of the world, and files, records, co-ordinates, and elaborates such data for current publication and special use. These documents are both printed and written in all languages, in divers weights and measures, and values represented by the coins of the world. Their receipt is necessarily irregular, coming from near and distant parts of the globe, freighted with news of crops ripening in every month of the year. There is great difference in the promptness of their preparation and in the degree of their accuracy, while many minor countries possess no statistical systems. These facts suggest the extent of the work and the difficulty of its efficient performance.

The work consists of the preparation of reports, investigation of industrial problems, collation of comparative international statements, responses to inquiries from foreign legations, from members of Congress, from rural and commercial bodies, and from editors and other publicists seeking information for immediate publication.

During the past year the official published reports have included the monthly series prepared by the Statistician, the annual report of statistics in the volume of the Department reports published by Congress, and an album of agricultural statistics. The latter is the initial publication of a series of graphic illustrations of agricultural statistics which has been demanded by educators and agricultural writers for years, as a means of popularizing such statistics.

The material furnished to officials of this and other countries, industrial and commercial organizations, editors, and writers, in manuscript form, has been scarcely less voluminous than the publications.

The crop-reporting system, which has been copied in many foreign countries and, in its main features, by our State statistical bureaus, while approximate and valuable, is in danger of becoming discredited by the popular acceptance of its results as exact in precision and absolute in authority. It should be remembered that they are not the conclusions of a thorough census, though they may be far better than the work of a poor census; that they are the consolidations of local estimates of agricultural experts, and are intended as a foil to the interested, biased, and untruthful statements that speculators issue to mislead their victims. It is recognized that producers, consumers, forwarders, and dealers in actual grain have a common interest in learning the exact truth of production.

The monthly crop reports of the Statistician are now limited to statistical correspondents and writers for the press, the brief telegraphic summary sent out on the 10th of each month being so sent out through the press associations. My present purpose is, that hereafter, at least during the crop season, a more extended summary

of each forthcoming report shall be prepared, in advance of its regular circulation, of which a large edition may be printed for transmission to agricultural and other weekly papers, to postmasters, farmers, and any others who desire to receive it.

THIS YEAR'S CROPS.

The statistical records of the season indicate an average yield of cereals, a full supply of meats of all kinds, and a cotton crop adequate for all demands. Potatoes have received some injury from rot, which has been more prevalent in the East than in the West. Fruits have been produced in only moderate abundance, apples especially yielding sparsely in the more favorable locations, and producing scarcely a third of a full crop. The increase in variety of fruits and in area occupied, in California and Florida, is yearly enlarging our resources and in some directions limiting importation of subtropical kinds.

The great crop of American arable culture, corn, is larger in breadth this year than ever before, comprising more than half the area of all cereals, and representing three-fourths of all the maize grown in the world. It promises slightly more than an average yield, which has been about 26 bushels per acre. Though slow in germination and early growth in the Eastern and Southern States, from excess of moisture and low temperature, the season was long and frosts late, with freedom from droughts except in local and very limited areas.

The production of wheat has for several years been so large as to reduce the price to a point so low as to discourage growers. There has been an increase of demand, since 1880, due to increase of population, of 70,000,000 bushels, and a decline in foreign demand of about 65,000,000 bushels. The exportation of 1880–'81 was 186,321,514 bushels, in wheat and flour; the average for eight years since has been 121,300,638 bushels. This country still supplies the larger part of the European deficiency, which is much smaller than in the period of poor European harvests about ten years ago. The present crop will be a full average (between 12 and 13 measured bushels per acre), but the quality is below an average, with lower weight and bread-making capacity. There is an ample supply, however, for all probable European demands, though deficient yields elsewhere should tend to sustain if not to advance prices.

The product of cotton approximated closely 7,000,000 bales for the first time in 1884. The crops of 1887 and 1888 each attained about the same volume, and that of 1889 has a slightly increased area, while the October percentage of condition was somewhat higher than last year, giving promise of another large crop. Yet it is acknowledged to be late, subject to unusual injury from possible early frosts, and therefore as yet uncertain in its rate of production. It is gratifying

to observe that this product still meets with ample demand and maintains its value in the markets of the world, the production of the United States as well as of the world's consumption having nearly doubled within thirty years. There is no immediate prospect of the loss of this supremacy in cotton growing.

The necessity of economy in meat production has stimulated greatly the production of hay and dried forage, and the extension of the silo system, which has been encouraged by the demand for succulent feed in the absence or scarcity of roots, has greatly enlarged the variety and volume of feeding material. In the arid regions alfalfa has absorbed a considerable area of irrigated lands, and is assuming large proportions in the crop distribution of those areas. The increase of forage and hay is relatively greater in the South than in any other portion of the country.

THE ROCKY MOUNTAIN REGION.

The development of agriculture in the Rocky Mountain districts has been very rapid of late, and is full of promise for the immediate future. Millions of acres are already under irrigation, with results more certain and satisfactory than in States solely dependent on current rain-fall. New enterprises are in progress, and Government surveys for highland reservoirs have been initiated. Already the value of the products of agriculture on the Pacific coast, if not in Colorado, in the heart of the mountain system, is greater than that of the products of mining. The Division of Statistics, under my direction, is investigating these resources and measuring their development, with all the facilities at its command. The results will surprise the Eastern States with new views of the wealth and progress of the Great American Desert of the recent past.

The work of this division is presenting to the world the marvelous results of our agriculture, which supplies our rapidly increasing population with rations greatly in excess, in quantity and variety, of any other nation on the globe, and appropriates a larger surplus, both in volume and proportion, to supply the deficiencies of foreign markets than any other country is able to spare.

It is gratifying to note the appreciation of the work of the Division of Statistics by statesmen, publicists, and statisticians of this country, and to acknowledge similar high commendations from prominent foreign editors, and from executive statistical officers of foreign Governments, some of whom have declared the body of agricultural statistics of the Department of Agriculture of the United States the best in the world.

It is proposed, in response to repeated inquiries, to give special attention to local statistics, to concise yet comprehensive agricultural surveys of States and Territories, which will give a fair and full showing of natural resources and their development, without color-

ing from local pride or pecuniary interest, and yet appreciative of natural advantages only partially improved. It is desirable that local capabilities should be accurately presented and worthy of the confidence of those who discredit the extravagances of immigration solicitors and land speculators. The plain truth is quite as much as the eastern inquirer can be induced to accept. It is regretted that available means will only suffice for a beginning of this work, which should be presented hereafter more rapidly and promptly as statistical appropriations shall warrant.

It is my intention next year to make an effort, through the medium of our numerous county statistical correspondents, to bring the Department into closer touch with the farming community at the county fairs held throughout the country. At a trifling expense these county statistical agents should be enabled to attend their several county fairs, armed with a commission to report to this Department as to the character and extent of their exhibits, both of field products and live stock, the amount of premiums conferred, manner of judging, etc. At the same time these agents would be authorized to secure for this Department, as far as practicable, samples of the finest exhibits of field products, thus furnishing the most tangible evidences as to the character of the products and the agricultural possibilities of all sections of the country. An immense amount of time and money is expended in the aggregate upon these county fairs. To what extent they may be made subservient to the duties of this Department is necessarily a matter of speculation, but I am convinced of the propriety of endeavoring to utilize these gatherings in some such way as I have indicated. Everything that leads to a more intimate acquaintance between the Department and the farmers throughout the country must be mutually advantageous

DIVISION OF ENTOMOLOGY

The results of the labors of this division have been of great importance, and in no direction more than in the outcome of the effort to import the parasites and natural enemies of the Fluted Scale insect of California. The entomologist, after careful investigation, satisfied himself that this insect, which of late years has so seriously affected orange culture in southern California, was a native of Australia, and was comparatively harmless there, owing to the natural enemies which kept it in check and which had not been imported into this country with it. Efforts, through correspondence, to import one of the parasites that had been studied proved but partially successful, and the Department was anxious to take advantage of the Melbourne Exposition to have agents visit Australia with the express object of helping to import these enemies of the Scale alive. Accordingly, an arrangement was made with the Department of

State whereby two of the salaried agents of the Entomological Division were to be sent to Australia, the one with instructions to report on and send over the enemies of the Scale insect, the other to report to Mr. McCoppin, commissioner to the Melbourne Exposition, on the agricultural features of the exposition, the State Department defraying their expenses.

The results of this undertaking have more than justified the most sanguine anticipations. Several of the parasites have been introduced and acclimated, while one of the predaceous insects thus imported, viz, a lady-bird (*Vedalia cardinalis Mulsant*), has increased so enormously and is so active an enemy of the Scale that several important orchards have already been completely freed from the pest by its agency, and despondency has given way to hope and confidence among California orange-growers. The result furnishes a most striking illustration of widespread benefit resulting from scientific investigation and effort.

The year has been remarkable for the great prevalence of blights, both of a fungus and insect nature. The most serious insect outbreak of the year was the appearance in enormous numbers in the wheat-fields of Ohio, Maryland, Wisconsin, Michigan, and Illinois of the grain aphis. This insect remained in the fields in injurious numbers much later than in ordinary seasons, and the result has been considerable shrinkage of the crop in the infested States. This pest has been carefully studied and data have been collected.

For the past few years there has been much complaint from the orange-growers of Florida of a new pest in the shape of a leaf-mite which causes an injurious shedding of the foliage in the winter, and which has made its appearance since the completion of the special investigation of the insect enemies of the orange. This mite has been the subject of special investigation during the year.

Much time has already been given to the thorough investigation of the horn fly, a pest to horned cattle newly imported from Europe. This insect was first noticed in this country rather more than two years ago in the vicinity of Philadelphia, and has since greatly increased and spread to the southward along the Atlantic States until it has now reached southern Virginia. It is a serious drawback to the stock and dairy interests of the localities which it has reached, very greatly reducing the condition of cattle and the yield of milk. The complete life history has been followed out and field experiments have been made which result in establishing satisfactory remedies and preventives.

The publication of the report of the investigations of the injury to the roots of peach and other crops in Florida by swellings caused by sel-worms has been unavoidably delayed on account of matters connected with the illustrations, but it has now been published as Bulletin

20 of this division, and will doubtless prove of value not only to horticulturists and fruit-growers in the South, but to gardeners in other parts of the country, as allied worms are found throughout our entire territory.

The publications of the division have also occupied a considerable portion of the time of the office force. The periodical bulletin, *Insect Life*, has been issued regularly every month, and its usefulness and popularity are shown by the great demand for it. The wisdom, which has never been questioned, of establishing this means of communication with the farmers and working entomologists has become more and more apparent, and the editing and oversight of its monthly numbers has come to be one of the most important of the Entomologist's duties.

The Bibliography of Economic Entomology which was ordered by Congress in July, 1882, is now nearly completed. The extent of the work made it advisable to publish it in several parts, and Parts I, II, and III are now rapidly going through the press.

SILK CULTURE.

The interest in silk culture still remains unabated. The correspondence in no other division is more widespread or in larger proportions, showing a conviction in the public mind that success is possible. There seems to be no question that the mulberry tree can be grown and the cocoon produced economically in a large area of this country. The fact that this culture up to the production of the cocoon can be made largely a household affair, and needs no large expenditure of money, and that the sums, small though they be, realized from the sales of cocoons would be a blessing to innumerable families, an income added to without in any way interfering with the regular occupation which provides daily support, leads me to desire to continue the work as laid down by Congress. The real question, however, is the market for the cocoons, which need to be reeled before the silk is fit for the spinner. In competition with the hand-reeling of other countries the industry here would fail, as the difference between the cost of reeling here and the cost there would manifestly be deducted from the price paid for the cocoons, and would so reduce their market price as to discourage the industry of raising them.

The prime effort of the Department in this work is properly in trying to perfect an automatic reel that shall substitute machinery for manual labor in reeling. While success in this direction is not yet secured, the prospects are sufficiently favorable to make me hopeful of ultimate good results. Mr. Philip Walker was dispatched to Paris a few months ago with instructions to study fully and carefully the whole subject of silk-culture, especially in its relation to our own efforts,

and with a view of ascertaining what progress and improvements are being made abroad. He has not yet returned, and beyond the usual annual appropriation for the continuance of the work I must refrain from making specific recommendations until I have before me the results of his investigations.

CHEMICAL DIVISION.

The work of the Chemical Division has been vigorously carried on under disadvantages and discomforts to which I have heretofore alluded. In accordance with a law enacted at the last session of Congress, providing for an extension and continuation of the investigation of the adulteration of foods, drugs, liquors, etc., the division has completed two parts of Bulletin No. 13, consisting of Part 4, which treats of lard and its adulteration, and Part 5, which treats of baking powders, their manufacture, use, and chemical composition. In accordance with the requirements of the act alluded to, I shall, in due time, make a separate report to Congress of the operations of this division under the said appropriation. In addition to these investigations very complete analyses have been made of sorghum seed to establish their value as a cattle-food, and investigations have also been made upon the seeds of calacanthus growing wild in the mountains of North Carolina, and which prove very poisonous to cattle eating them. From these seeds a new alkaloid has been separated and its properties described.

Important investigations have been carried on in the Chemical Division to determine the influence of different kinds of food upon the composition of butter. These results have proved of the greatest interest, and have shown that the quality and composition of the butter are greatly influenced by the character of the food used.

SORGHUM AND BEET SUGAR.

The Chemical Division has also conducted during the past year additional experiments looking to the manufacture of sugar from sorghum and sugar-beets. Chemical laboratories have been established in connection with the sorghum sugar factories at Rio Grande, N. J., Morrisville, Va., Kenner, La., Cedar Falls, Iowa; and at the following points in Kansas, namely: Sterling, Ness City, Conway Springs, Attica, Medicine Lodge, Minneola, Mead, Arkalon, and Liberal. The results of the season's work are not yet fully collated, but a general idea of them may be expressed. In New Jersey and Virginia the late, wet spring and the remarkably wet summer prevented the maturity of the cane, and thus prevented the successful manufacture of sugar. The results obtained in Louisiana were of a mixed character. In some cases considerable quantities of sugar were made per ton of cane, in one instance over a hundred pounds;

while in other instances the results were of a most disappointing character. The results of experimental work at Cedar Falls, Iowa, were also of a discouraging nature. No sugar of any consequence was made; and it may be stated that while as far north as Cedar Falls molasses may be made with profit, it is probably too far north to permit of the successful manufacture of sugar from sorghum.

The results of the experiments in Kansas have shown that in the extreme western portion of the State the season proved too dry for the production of a crop of sorghum cane suitable for sugar-making. On the other hand, in the southern portion of the State, west and south of Wichita, fine crops of sorghum cane were produced, and sugar made in such quantities as to foreshadow the financial success of the industry in those localities and in places farther south. The general result of the recent experiments in the manufacture of sugar from sorghum carried on by the Department has determined the localization of this industry, in so far as financial success is concerned, in the region indicated above. If success attend the sorghum-sugar industry in the future, there seems to be reasonable ground for believing that in the southern part of Central Kansas and in many parts of the Indian Territory, where the soil and climate are similar to that part of Kansas mentioned, it may especially flourish. There are, perhaps, also other parts of the United States where similar success could be secured, but these have not yet been pointed out.

Important progress has also been made during the past year in the development of varieties of sorghum containing a higher content of available sugar than those heretofore grown. These experiments have been carried on at Sterling, Kans., and at College Station, Md. Similar experiments have also been conducted in connection with the manufacturing work at the places mentioned above. A large number of analyses have been made during the last year and the present season for the purpose of selecting for planting the seed of those varieties and individuals whose juices show the highest percentage of available sugar. The results have gone far enough to justify the belief that by a selection of this kind a permanent improvement can be secured. It is certain that should the sorghum-sugar industry prove successful, the growth of the seed will be a separate business controlled by experts and carried on under those conditions most favorable to the production of the highest content of sugar. What can be accomplished in this line has already been illustrated with the sugar-beet, and there is every reason to believe that equally favorable results can be secured with sorghum.

In regard to the beet-sugar industry, experiments have been made in various parts of the United States in the growth of beets and in the analyses thereof. Many of these analyses have been made in the Chemical Division of the Department at Washington, and show that there are many localities, especially in the northern portion of the

United States and on the Pacific coast, suitable to the production of a sugar-beet rich in saccharine matter. The successful experiments in beet-sugar manufacture in California have created a great deal of interest in various parts of the United States in this industry, and the Department has received many inquiries for information on this point. The Chemical Division is now collecting material for a full report on the beet-sugar industry in the United States, which it is hoped may be published early the coming winter.

BOTANICAL DIVISION.

Besides the general scientific work, which has been extensive, the special effort of the division has been directed to grasses and forage plants, and more particularly to those adapted to the Southern States and the arid and semi-arid regions of the West. A grass station has been conducted in connection with the Mississippi Agricultural Experiment Station for that region of the South, and one is being established in co-operation with the Colorado Experiment Station, which, with the independent grass station established last year at Garden City, Kans., that has been enlarged and more fully equipped, inaugurates the line of experiments contemplated for the arid region. The results of the year's work in both regions have been eminently satisfactory.

What the Southern States need at the present time, agriculturally, more than anything else, is a productive grass. The desire is to place stations at two places other than that in Mississippi.

The problem the Department is seeking to solve in the arid region is an increase of forage on the non-irrigable lands. There is far less need of experiments on the irrigable lands. What they are capable of producing is almost beyond computation, but the question whether the 300,000,000 of acres and more outside of possible irrigation can be quadrupled in forage possibilities, is of immense import. It is believed that as nature has selected the grasses growing there, a cultivation of the same must promote their productiveness there, as it does that of other grasses elsewhere. Accordingly wild-grass seeds are being collected and are to be propagated in the station there. The Department desires to establish, independently or in connection with the experiment stations, four more stations in the West, so as to cover all Western conditions.

The division has issued during the year Bulletin No. 8, entitled "A record of some of the work of the division, etc.," and has now in press a new revised edition of the "Agricultural grasses of the United States," a very comprehensive and practical treatise on this important product. It has distributed to seven of the Agricultural Experiment Stations each a herbarium of carefully mounted botanical specimens of grasses and species of our native grasses as types, ma-

terial very much needed at those new stations for the successful development of their work. It has had agents in various regions not yet fully explored, botanically, to collect specimens for our national herbarium, which will enable us to assist further the agricultural colleges, and also to make exchanges with and contributions to various foreign scientific societies. I consider the work of this division as judiciously planned, and if continued on the lines which I propose, it will place our botanical collection at the head, as it should be, of similar collections in the country, if not in the world.

During the past summer the chief of the division visited, by my direction, Kansas, Colorado, New Mexico, northwestern Texas, Arizona, California, and Utah, and spent two months in the investigation of the native grasses and of the climatic conditions of the arid districts, so as the better to be able to grapple with the forage problem of those States and Territories.

THE SECTION OF VEGETABLE PATHOLOGY.

The work in this section is very important. It covers the diseases of plants, their nature and treatment. During the last growing season agents were located in New Jersey, Delaware, Virginia, South Carolina, Mississippi, Missouri, Michigan, Wisconsin, and California to investigate the plant diseases peculiar to those localities—notably black-rot, downy mildew, and anthracnose of the grape, root-rot and rust of cotton, and pear and apple diseases. Special attention has been given to the *blight* of the Le Conte pear in southern Georgia, and to *peach yellows* in Maryland, Delaware, and other States. While successful treatment has not been reached in the former case, and the cause of the latter is still unknown, very substantial progress has been made in both, and in the latter there is promise of highly beneficial developments. It is too soon to predict as to the pear-blight, but the hope is awakened that a remedy can be found.

Within the last two or three years a most destructive disease of the grape-vine appeared in southern California, which promises, if not checked, to destroy utterly the production of grapes in that locality. An agent of the section was dispatched there last June who has instructions to remain on the ground indefinitely to study the nature of the disease, and, if possible, discover a remedy.

In all these cases the work has consisted largely of field examinations supplemented with microscopic work. The latter has given evidence that all the diseases, with the exception of the California vine trouble and the peach-yellows, are due to plant parasites, and from the evidence now at hand it is very probable that even the last two are caused by bacteria which attack the healthy plants as well as those lacking in maturity or vitality. Experiments are being conducted both in the field and in the laboratory to determine, how-

ever, the true nature of these diseases. The immense losses caused by them justify the amplest expenditures in seeking their natures and devising a remedy.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

Two distinct lines of research are carried on by this division; one devoted to the study of certain species or groups of species which are harmful or beneficial from a directly economic stand-point, and particularly from the farmer's point of view; the other—equally or even more important—a study of the fundamental facts, principles, and laws which underlie the present geographical distribution of life.

The primary object of mapping the geographical distribution of species is to ascertain the number, position, and boundaries of the faunal and floral areas of the United States, areas which are fitted by nature for the life of certain associations of animals and plants, and which, consequently, are adapted for the growth of certain vegetable products and for the support of certain kinds or breeds of stock. The results of this study of the natural *life areas* of the country are of the utmost value to practical and experimental agriculture, and are so intimately related to the work of the experiment stations that the investigations of the latter can not be fully utilized without a knowledge of the more important facts which the study of geographical distribution affords. The work of mapping the distribution of species has received as much attention as the limited funds at command would permit. The most important work in this line has been a systematic biological exploration of an area of about 5,000 square miles in extent in Arizona. This exploration was conducted by Dr. Merriam, Chief of the Division, assisted by Mr. Vernon Bailey, field agent, and resulted in the discovery of many species new to science, and in the acquisition of many facts of economic consequence. It was demonstrated that complete accord exists between the distribution of animals and plants covered by physiographical conditions. The boundaries of the areas inhabited by certain associations of species of birds and mammals and reptiles were found to coincide with one another and with the boundaries of the areas inhabited by certain species of plants. The knowledge of this fact emphasizes the importance of the study of the flora of a region in connection with the study of its fauna.

In the first line of work may be noted the compilation and publication of the bulletin on the English sparrow, a volume of 405 octavo pages, the demand for which was so great that thousands of applications for it were received in advance of its publication. Although so short a time has elapsed since its appearance, some of its good effects are visible already in the successful efforts for the restriction and extermination of the sparrow. The study of the food

of crows continues, and a bulletin will be ready for distribution before the close of another year. A full and copiously illustrated bulletin on hawks and owls is nearly ready for the printer. The collection of stomachs of birds believed to affect agricultural interests now number 10,675. More than 3,000 specimens of birds were received for identification between January 1 and October 1, 1889.

DIVISION OF MICROSCOPY

The work of this division is largely in the line of original microscopical investigation of food stuffs, including the condiments of commerce, and in preparing microphotographic illustrations of pure food products and of the adulterants used in them. The teas of commerce have been the subject of like investigation. It is found, it is claimed, that the leaf of the tea-plant has marked characteristics not found in any of the plant leaves used for adulterants. An extended investigation has been made relating to the color re-actions of the pure native olive oil from California, and of its adulterants, such as cotton-seed oil, oil of sesame, oil of poppy seed, and peanut oil. It is claimed that there are very marked color differences.

THE TEXTILE FIBERS.

I have given much thought, since assuming my duties, to the subject of fibers, a subject whose importance can not be overestimated, and I have found a wide-spread interest in the matter of a promotion of the cultivation and manufacture of flax, jute, and ramie, and other textile fibers. The correspondence of the Department on this subject has become very large. In the States of Indiana, Illinois, and all the Northwest, large amounts of flax are raised for the seed alone. The question now is, can not the fiber be utilized also? While the cultivation of jute and ramie can hardly be classed, as yet, beyond the experimental stage, enough has been grown to justify the belief that in most of the Southern States they can be produced in abundance and of good quality.

The question, therefore, is not so much whether this country can produce all these fibers as whether the farmer can find a market for those he may produce. The manual labor heretofore necessary in the separation of the fiber from the stalk has, in competition with the cheaper labor of other countries, rendered it impossible for the fiber industry here to maintain an economic standing, and our only hope lies in the invention of decorticating machines that shall take the dry stalk or the green one, as the case may be, and produce the fiber in one or, at most, two operations in a short time with a minimum of cost and without the primitive manual labor incident to the rotting, breaking, hatcheling, pounding, etc.

Within the last five years the mechanical genius of both continents has been directed to the invention of machinery to accomplish these results. It is claimed emphatically that there are one or more such for the rendering of flax. Several machines and processes for the rendering of the ramie fiber, which is far more difficult than that of flax, are claiming public consideration, but the tests of their efficiency at this date, as reported to this Department, have not fully demonstrated their economic success. Still, there has been such substantial progress made in the last five years that we seem to be approaching the solution of the problem.

Seeing the importance of this subject, I have taken advantage of the presence at the Paris Exposition of a gentleman versed in this subject, and have commissioned him to investigate all the fiber machines on exhibition there, to visit all the flax and hemp growing countries of Europe, to examine the flax machines in operation and the ramie machines wherever tested, and to report thereon fully. I am seeking for information from every quarter likely to give it, and to do all that can be done to promote an industry that will, if successful, save to this country $20,000,000 annually, and which may take the place of raising of wheat and other cereals in States where their production is not now profitable. I shall ask from Congress an appropriation to enable me to prosecute a more extended investigation of this subject.

AGRICULTURAL EXPERIMENT STATIONS AND OFFICE OF EXPERIMENT STATIONS.

As a central agency for the agricultural experiment stations of the country established by act of Congress it is the duty of the Department, through the office of experiment stations, to indicate lines of inquiry for the stations, to promote the co-ordination of their work, to furnish them needed advice and assistance, and to collate and publish the results of their experiments. To this end it conducts a large and increasing correspondence relating to the scientific, administrative, and general interests of the individual stations and the enterprise as a whole. Its representatives visit stations, agricultural colleges, and kindred institutions. It collects statistics and other information regarding agricultural science; compiles results of inquiry, past and present, in this country and in Europe, which are greatly needed and earnestly called for by the station workers and others interested in agricultural science, and puts the result of station work in practical form for general distribution in farmers' bulletins.

For the ensuing year this office needs means proportionate to the pressing demand for the enlargement of its work in all the lines named, including especially the collating of fruits of experience and making them available to the stations and the agriculture of the

country, and the promotion of inquiries of general importance in connection with the stations in different sections of the land. With other lines of inquiry the study of the far-reaching problems relating to the food and nutrition of domestic animals and of man, and the systematic investigation of our soils already begun, in accordance with special provision by act of Congress, should be undertaken on a broad and scientific basis.

The development of the experiment-station enterprise in this country is a noteworthy illustration of the readiness of the American people to grasp and to utilize new and valuable ideas. Beginning only fourteen years ago, it has grown out to the farthest limits of the land, enlisted the best colleges and universities and the ablest investigators, and secured both State and national resources for its maintenance. It now employs nearly four hundred workers "to promote agriculture by scientific investigation and experiment," and to diffuse as well as increase the knowledge which improves farm practice and elevates farm life. It has the favor of a great army of practical farmers, to whom it has already brought substantial benefits. The experience thus far gained evinces the wisdom of Congress in distributing the work throughout the country where it may be adapted to the wants of the various sections, and placing it in connection with institutions of learning which are, in general, laboring faithfully to fulfill the trust imposed upon them.

Crudity and mistakes are here and there apparent. But the general effort of the stations toward the greatest usefulness, the wise action of the Association of American Agricultural Colleges and Experiment Stations, the cordial support of the people, State legislatures and Congress, and the practical results already obtained, imply that the National Government has made no mistake in undertaking this enterprise on a larger scale than has been attempted elsewhere in the world. At the same time we should remember that quality more than magnitude decides the value of every enterprise, and that this one can attain its highest success only in proportion as the laws which underlie the practice of agriculture are discovered and made available to the practical toilers of the farm.

FORESTRY DIVISION.

Only very slowly are our people beginning to realize that our natural forest resources, subjected to wasteful methods and unprotected against the ravages of fire and other destructive agencies, are liable to deterioration if not exhaustion, although capable by the application of proper management of yielding continual crops of valuable material. Blind to the experience of other nations, we must learn by experience at home that the condition of our water-sheds and river systems is, to a large extent, influenced by a condition of our forest areas.

Forest management under existing circumstances does not attract private activity, and it would seem to be the duty of the Government to assume a more definite supervision of such forest areas as are still owned by it, and as occupy a position of importance in the regulation of water-flow and of other climatic conditions.

The relations which these forests bear to the water conditions and river systems of the Rocky Mountain region and to the problems of irrigation in the arid lands is a matter for grave consideration.

A further practical work would consist in experimenting as to the possibilities of reforesting the now treeless regions of our country.

This division was designed to serve as a bureau of information in regard to the forestry interests of the country. Its work in the beginning was naturally tentative, and the information could only be of a general character, having in view primarily the creation of a more general interest in the subject. With the growth of interest in forestry and a better understanding of its usefulness and desirability, the information asked has become more specific, and to supply this better facilities are needed. We must be able to supply information as to the present extent, location, and condition of forest trees, their present yield and future promise, the progress of deforestation by various agencies, the progress of reforestation by private enterprise, and the bearing which these processes have upon lumber supply as well as upon the country at large. We are at present without definite knowledge of the extent, location, and direct or indirect value of the forest property which has remained in the hands of the General Government, much less of the forest condition of the country.

Statistical information of this kind can be had only by means of a thoroughly organized canvass, with ample appropriations. The division has heretofore had to confine its work mainly to supplying such information as could be gained by scientific studies, by observation, by consulting the literature, foreign and domestic, on the subject with the view of advancing our knowledge of forest management and forest planting, of the life history of our trees and of the properties of their timber.

The biological studies and the investigations into the technical properties of our timbers have been continued, and the publication of some of the monographs relating to the life history of our most important conifers is contemplated within the year.

The relation of various industries to forest supplies has been made the subject of inquiry, especially that of the cooperage industry, and the carriage and wagon manufacture.

The important question of substituting metal for wooden ties, treated of in Bulletin No. 1 of this division, has received additional consideration in Bulletin No. 3, published this year as a preliminary report of an inquiry into the practicability of such substitution and

the extent to which it has taken place in this and foreign countries.

A full report on this subject, with additional information regarding the progress of the methods and application of wood preserving processes, is in preparation.

The provision of the law which calls for the distribution of plant material could be satisfied only in a very limited way, in proportion to the limited appropriations.

The collection of information naturally leads to the collection of material from which information may be derived. Attention has, therefore, been given to the establishment of a collection of forest botanical specimens, the absence of which has been a long-felt drawback to the work of the division. In addition, a tolerably complete collection of forest-tree seeds has been gradually brought together, which permits the control as to kind of seeds purchased and prevents the danger of substitution.

The library of reference books in forest literature of this and other countries, although by no means complete, has also been enlarged, so as to make the facilities of the division for the student of forestry, in that respect at least, what they should be, the best in the country.

The magnitude of our forestry interest is best represented by the statement, based upon the best authorities available, that our present annual forest production amounts to $700,000,000, a figure which it seems likely could, by judicious management of our present forest area, be maintained if not exceeded without impairment of the capital from which it is derived.

DIVISION OF GARDENS AND GROUNDS, HORTICULTURE, ETC.

The duties of this division consist, partly, in keeping in proper condition the roadways, walks, trees, and crops on the forty acres of reservation known as the Grounds of the Agricultural Department; the management and care of the plants in the conservatories, propagating houses, and other glass structures; the introduction, propagation, and culture of economic or useful plants, and the distribution of such plants in localities where climatic and other conditions seem favorable to their growth.

The main feature of interest in the ornamental portion of the grounds is the method employed in grouping trees and shrubs. These are arranged in strict accordance with a botanical classification, at the same time securing landscape-gardening effect.

The portion originally set apart for out-door propagation and for gardening purposes has been abridged by the erection of buildings to accommodate the increasing operations of the Department; consequently the testing of new varieties of fruits, formerly a prominent feature in the work of this division, has been virtually abandoned.

The exposed position of the grounds also militates against the accuracy of such tests.

I would here refer to the recommendation made elsewhere in this report in regard to the Arlington estate. The work of testing these new varieties of fruits is too important to have been allowed to lapse. It ought to be resumed at the earliest moment practicable, and such a disposition of the 300 acres of the Arlington estate as is elsewhere proposed would enable the Department to resume its work under the most favorable circumstances.

In the propagation of plants intended for distribution a distinction is made between those of mere ornamental value and those that represent economic products; therefore the introduction and propagation of specialties, of plants which are either new or rare, so far as relates to the value of their products, or older varieties which commend themselves for particular purposes for which their extension is deemed desirable, are the important considerations which govern operations in this line.

While the requests for plants are unlimited as to kinds, the Department reserves the prerogative of the selection of such as may be adapted to certain localities. In this discrimination the results of experiment with former introductions and distributions are duly considered.

As examples, the records of the Department show that the genus Eucalyptus, of reputed anti-malarial value, can not withstand the climates north of latitude 29°. The quinine-bearing Cinchonas have been so far tried throughout the States that localities where further tests are wholly unnecessary are now well defined. The same tests have been made with the tea plant, the coffee plant, with olives, Japan persimmons, pine-apples, etc., so that the climatic conditions for their successful culture are sufficiently known to guide the Department in its further distributions of these plants.

As a main purpose of the Department is that of introducing, or assisting the introduction, of new or but little known useful plants, it will have served this purpose when these plants have either merited the attention of cultivators or have proved to be failures; in the former case their further propagation is taken up by commercial growers, who can supply all demands, so that the services of the Department are no longer important in that particular plant, and its means can be directed and employed for other purposes of a similar character.

Urgent demands are constantly received from residents of the warmer climates of this country for all kinds of tropical plants, many of which, even if a suitable climate is found for their growth, can only be classed as ornamental plants; but useful plants of this nature, such as the vanilla, the chocolate, and others of similar habits and value, are distributed to some extent for trial; but the portion of this country, if any, suited to these is very limited indeed.

SEED DIVISION.

The distribution of seeds to experiment stations and agricultural colleges has now become an important part of the work of this division, and the wisdom of this course is so apparent that the policy of placing seeds of new and presumably valuable plants at the disposal of the officers of these institutions will be sedulously adhered to. From them the Department may reasonably anticipate getting such reports, including such data as the date of sowing or planting, the time of maturing and harvesting, the quantity of seed planted, the amount and quality of the product, the character of the soil and climate, as will enable the Department to arrive at reasonable conclusions as to the relative value of seeds so furnished, so that we may then be more certain of furnishing to our farmers in the various sections represented by these institutions the seeds best adapted to their wants and most certain to insure them good returns.

With a view to securing the best seeds, I have made a departure from the methods heretofore in vogue by engaging the services of a special agent, whose whole duty it is to visit, personally, different sections of the country and inspect, as far as possible, the product of seeds offered to the Department, and to look up such as seem to possess specially desirable characteristics. The work done in this line has more than justified the expediency of undertaking it. The results which may be secured by wise dissemination of seeds are of great value. By the substitution of superior varieties for such as have become deteriorated or diseased, and by the introduction of the seeds of new plants, through the cultivation of which the resources and wealth of our people may be largely increased, the producers of this country can not fail to reap very great benefits.

The distribution of seeds during the present administration has, of course, not been very extensive, as this covers the season of least activity in such work; but the distribution of winter wheat has this year been greatly increased, and has attained that place in the full distribution which its evident importance warrants. I wish here to emphasize the necessity of close observation of the products of those countries which compete with ours in the cereal markets of the world, and of procuring from time to time for experiment and analysis in this country the seeds of such varieties grown abroad as seem to have specially desirable qualities. The vast extent of this country, with its great varieties of soil and climate, justifies the belief that there is no cereal grown abroad which can not be equally well grown, and indeed improved, in some sections of this country. In pursuance of this consideration, I have caused to be purchased a suitable quantity of five superior grades of wheat grown on the shores of the Mediterranean, which will be carefully tested and judiciously distributed with due reference to conditions of growth.

In this connection I may state that especial care is being taken to discriminate in the distribution of all seeds according to the varying conditions of soil and climate. In the face of increasing competition, it becomes necessary that we should, in addition to advantages afforded us by cheap lands and facilities for transportation, strenuously guard that guaranteed to us by the superior excellence of our products to those grown elsewhere. This can only be done by constantly seeking out the best that there is, and securing its dissemination in sections of this country where it can best be grown. This excellence must moreover be made so apparent as to be undisputed. The time has come for chemical analysis to aid in determining the relative value of cereals whose merits on the market have hitherto been usually determined simply by the eye, and for this reason I trust the Chemical Division may be so liberally equipped as to enable this Department to carry out a careful comparison between home-grown and foreign grains, proving conclusively, as I believe such a test will, the superiority of our cereals for milling purposes over those grown in competing countries.

The employment of a competent expert is contemplated in order that this Department may be enabled to exercise, in reference to cereals, the same duty as to inspection and nomenclature of different varieties which has been so efficiently performed in the botanical and pomological divisions in regard to grasses and fodder, plants and fruits.

In view of the growing tendency in the South to increase its grass products, a tendency which should be fostered by the Government, I have ordered a supply of Bermuda grass for distribution throughout the Southern States. The advantages of this grass for our southern latitudes are manifest and generally recognized, but being a very spare seeder, and the imported seed not always to be had and quite expensive, its cultivation on a large scale has not been feasible. I trust to be able to counteract these disadvantages by a liberal distribution, as it spreads rapidly by its rooting stems when once introduced, and will prove a valuable permanent pasture south of 36° north latitude.

DIVISION OF POMOLOGY.

Two important trips of investigation have been made during the present year. The pomologist personally visited the State of Florida during the earlier months of the year that he might have a thorough and personal knowledge of the peculiar conditions existing there, and to see the citrus and other fruits in the orchard.

One of the regular employés of the division was sent, in company with a special agent of national reputation, as an expert scientific pomologist, on an extended tour of investigation through the regions from Texas and Wisconsin to the Pacific coast. Much

valuable information and a large collection of specimens of the wild fruits were secured. It is expected that this will materially add to the ability of this Department in assisting in the solution of the question as to what will be done with the arid regions.

The knowledge of those fruits which do or do not grow naturally in the unsettled portions of our country will in a measure indicate those of our cultivated kinds that may be expected to succeed or fail in those localities.

More than five hundred packages of fruit have been received within the year, and most of them were sent for the purpose of identification.

This is a matter that requires the most expert knowledge carefully used, for the variations of climate often so change the size, color, flavor, and season of ripening, as to deceive even the most experienced. However, with very few exceptions satisfactory conclusions have been reached.

It is often important, indeed essential, that the name of a fruit be known by the nurseryman or grower, for it would not be possible otherwise to intelligently propagate and distribute the trees or plants, or to cultivate and market the fruit to the best advantage.

It is the constant aim of this division to keep fully posted as to all new fruits, whether good or bad, and to embody in the annual and special reports a statement as to the real value of each. Almost daily the pomologist is called upon to pass opinion as to the merits of new varieties, and the greatest caution has to be exercised in the expression of such opinion.

Whenever it is possible to obtain new fruits that promise well they are distributed where they are most likely to succeed best. The division co-operates with the State Experiment Stations in this regard, and with private experimenters of high repute.

Quite recently the first lot of named varieties of cocoanuts ever introduced into this country was imported from the Philippine Islands by this division. Several other fruits have been introduced from Europe, India, and Japan, and arrangements have been made for procuring a number more.

THE FOLDING-ROOM.

The increase of labor in the Folding Division for the past few years has been very great. Looking back to the records of the Department prior to 1881, I find that the work in this division was so light and comparatively unimportant as to not even be made the subject of a separate reference in the Commissioner's annual report. To go back to the date when it first assumed dimensions which seemed to call for such special distinction (1881), I find that, including the special and miscellaneous reports, the total number mailed

in that year by this division was 259,000. Referring to the list of publications issued during the current year, I find that it has attained for the past nine months the very large number of 469,100. In addition, there is a very large amount of miscellaneous work, the increase in which has been even greater than in the number of reports mailed. In addition to this total of publications received of 469,100, there were also written franks and letters to the number of 801,500; advance sheets for the press, folded and directed, 60,000; packages of envelopes and paper sent to correspondents, 10,530, and return postal-cards mailed to the number of 20,000.

All this great increase of work has had to be performed with little or no increase in clerical force since the date mentioned, and with no additional facilities, and I can not insist too strongly upon the necessity of providing this division with such force and equipment as will enable it to do the work assigned to it promptly and efficiently. It is as objectionable as it is short-sighted that after expending a vast amount of time and labor in the preparation of important documents the Department should, for want of adequate means, be hampered in its efforts to lay them before the people who need them.

I append a list of the publications issued from this Department during the current year, with the number of each published and distributed:

SUMMARY OF PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE.

Issued and distributed from January 1, 1889, to October 31, 1889 (nine months).

Annual Report, 1888		30,000
Statistical reports:		
Monthly reports, new series, Nos. 59 to 67, inclusive, 19,000 of each	171,000	
Album of agricultural statistics	10,000	
		181,000
Botanical Division:		
Bulletins Nos. 8, 9, and 10, 5,000 each	15,000	
Special bulletin on the agricultural grasses of the United States	10,000	
		25,000
Section of Vegetable Pathology:		
Nos. 1, 2, and 3 of the Journal of Mycology	4,100	
Circular No. 8, pear-leaf blight, and apple powdery mildew	5,000	
Special reports on peach blight and potato rot	2,000	
		11,100
Chemical Division:		
Bulletin No. 13, parts 4 and 5, 10,000 each	20,000	
Bulletins Nos. 20 and 21, 10,000 each	20,000	
Bulletins Nos. 22 and 23, 5,000 each	10,000	
		50,000
Entomological Division:		
Insect Life, Nos. 7 to 12, inclusive, of Vol. I, 5,000 each	30,000	
Insect Life, Nos. 1 to 4 of Vol. II, 5,000 each	20,000	
		50,000

Forestry Division:		
Bulletin No. 3		10,000
Bureau of Animal Industry:		
Report on hog cholera	10,000	
Report of U. S. Board of Inquiry concerning epizootic diseases of swine	5,000	
		15,000
Ornithological Division:		
Report of ornithologist	2,000	
Bulletin No. 1, English sparrow	15,000	
		17,000
Office of Experiment Stations:		
Bulletins Nos. 1 and 2, 5,000 each	10,000	
Bulletin No. 3	10,000	
Miscellaneous Bulletin No. 1	5,000	
Farmers' Bulletin	50,000	
Special Circular No. 7	5,000	
		80,000
Total		469,100

THE LIBRARY.

An essential to efficient work is a well-selected and well-stocked library, which shall cover all the lines of inquiry of agriculture and agricultural science. It is useless to attempt to do first-class work that shall pass the scrutiny of the sharpest criticisms without having at hand what has been done and said in the past and what is constantly coming in from a prolific press. Our library, of something like 20,000 volumes only, is specially weak in the Government publications, some of which are of rare merit; in the agricultural reports of the several States, for which there is a great demand; in general agriculture, without which no one can well treat agriculture historically; in foreign agricultural reports and publications, without which in these times of cosmopolitan thought and work no such library as ours is properly equipped, and in several lines specially needed by the respective divisions of the Department. All the divisions need strengthening. The library has but a fugitive volume or two of any herd book, and is so woefully lacking in many lines that I refrain from further specifying.

In the change of the library from the old room, which was so small as to compel a suspension in a measure of the collection of more books and the rejection of the Government publications, to ampler quarters, it was, for want of help, badly disarranged, so that what we had was so difficult to find that it was almost a bar to any attempt to make a comprehensive study of any topic. A special effort has been made to re-arrange and reclassify it, and we now hope for a more satisfactory use of what we have, and for an appropriation sufficient to fill up the gaps and place it on a proper footing.

THE MUSEUM.

I am making an effort to place the Museum on a broader basis, not so much in the line of curiosities, which will not be ignored, as in the exhibit of the agricultural products of this and other lands. I am also endeavoring to procure samples of the four hundred and more supposed varieties of wheat grown in this country; likewise of all the varieties of corn, oats, and other cereals. With the collection of such an exhibit must be associated an expert, who shall, as elsewhere stated, be able to detect synonyms, and who shall be competent to pass judgment upon the changes marking the growth of the same variety in different latitudes and under different conditions of soil and climate. The importance of having a standard for the naming of the varieties is becoming more and more apparent. This is true likewise in relation to fruits. The new varieties now being so rapidly developed by the horticulturists of the country will soon swamp their nomenclature unless some place for scientific classification be provided, and it is suggested that the proper place is in our Museum, which should become the great agricultural museum of the country.

The Museum is now specially strong in native woods, and has a fair exhibit of wools and textile fibers. The latter should be largely extended. The fabrics from agricultural products should have a much larger display, and models or drawings of agricultural implements, both ancient and modern, should find a place in it. In short, this Museum should at the same time be an instructive object-lesson of the agricultural products and possibilities of the country, and should be a standard for accurate knowledge and for practical and scientific reference.

AMERICAN AGRICULTURE AT THE PARIS EXPOSITION.

It must be gratifying to all American citizens to note the tribute paid to the excellence of our American agricultural products at the recent Paris Exposition. The late date at which the appropriation was made available for the work assigned to this Department was a serious drawback, but in spite of this fact the high place of American agriculture in the estimation of eminent foreign authorities is attested by the liberal share of awards conferred at Paris upon the United States agricultural exhibit. The thanks of the Department are due to those public-spirited citizens who cheerfully contributed in response to its invitation towards this exhibit.

CORRESPONDENCE.

The growing appreciation of the Department among the people has no better index than the increasing number of letters received. All the divisions are nearly overwhelmed with the correspondence re-

ferred to them for consideration and reply, and from month to month and year to year the volume of it grows so as at times to almost cause suspension of regular scientific work.

These letters in large proportion are not the merely formal requests incident to departmental work, which any experienced clerk can answer, and which are increasing with accelerating rapidity, but relate to every possible question, from the most frivolous to the most abstruse, some of which may require days and perhaps weeks and the attention of several divisions to investigate and properly answer. The Department, as now administered, is a bureau of information on all subjects relating to agriculture—from the weather, the crops, to the ravages of the smallest insect and the most minute fungus. The people are appreciating this personal information and this consideration of their difficulties, and we attempt to answer their inquiries promptly and thoroughly, promptness at times being the essence of value to the inquirer. As an indication of the magnitude of this line of work the reports to me show that there have been received and answered since January 1, 1889, the following number of letters:

By the Bureau of Animal Industry	2,000
By the Division of Botany	957
By the Division of Experiment Stations	4,220
By the Division of Pomology	1,600
By the Division of Entomology	2,851
By the Section of Silk Culture	5,110
By the Section of Vegetable Pathology	2,000
By the Division of Ornithology and Mammalogy	3,036
By the Division of Forestry	1,000
By the Division of Accounts	5,875
By the Division of Chemistry	1,477
By the Division of Statistics	4,530
By the Folding-room	1,500
By the Office of the Secretary	3,000
By the Office of the Assistant Secretary, since instituted	750
Total	39,906

It must be borne in mind that these letters come from all sections of the country, from all classes and conditions, inspired by the wants of the most diversified country on the globe. This Department is for the people, for the struggling farmer, and there is no desire to abridge this labor, but my wish is to bring our work nearer their personal interests, and to make them feel, in every way possible, that we are helping them in their struggles, under, at times, adverse circumstances.

AGRICULTURAL ORGANIZATION.

In 1885 this Department prepared a directory of the officers of agricultural associations and organizations, local, State, and national, which then included some 5,000 names. I have just completed a

similar work for the current year which includes over 9,000 names. These associations represent so many centers of agricultural thought and effort at self-improvement, including a membership composed almost exclusively of practical farmers associated together in an effort to better themselves by improvement in methods and by the diffusion of greater light on the farming industry. I can not conceive of any more important duty devolving on this Department than that of giving aid and encouragement to these farmers in their effort to better their condition, an effort whose success means an addition to the wealth of the country. The least that should be expected of this Department is that it should furnish one set of its publications to any or all of these associations for the use of its members, and yet the largest printing appropriation ever devoted to the services of this Department would be quite inadequate to the purpose. To such an extent, however, as the liberality of Congress will permit, I shall make it my business to cherish to the utmost all such societies as are the outcome of a determined effort on the part of the farmers to help themselves. It is to be regretted that the narrow limits of the current year's printing fund forbids the publication of this directory for the present.

The figures here given afford eloquent testimony to the remarkable progress in the direction of self effort on the part of the farmers themselves. An increase of these organizations in four years at the rate of 1,000 a year is an evidence of this spirit which it should be the first duty of the Department to encourage. Another gratifying illustration of the same fact is the development of the

FARMERS' INSTITUTES.

Referring to these most useful meetings, I can not allow my first report as Secretary of Agriculture to go out without calling special attention to them. I regard this institute work as one of the most beneficent movements the agricultural history of this country ever has witnessed. My attention has been called to a bill introduced at the last session of Congress appropriating a liberal sum to establish in connection with this Department a division whose special duty it shall be to aid in the work of farmers' institutes throughout the country. I would merely say on this subject that it is a matter of no little gratification to me that this great work has nowhere been more fully tried than in my own State, where it was my privilege and pleasure to encourage it in every legitimate way, and nowhere has it reaped a more abundant harvest than in Wisconsin. Experience there and in other States has fully demonstrated the extraordinary benefits arising from these institutes, and I am strongly of the opinion that, without going into details as to the precise way in which aid to the movement should be furnished, the National Government, in pursuance of the policy so strongly marked out by the establish-

ment of the agricultural colleges and experiment stations, should put it in the power of the Department of Agriculture to foster and encourage the work of the institutes in the various States and Territories. The institutes have been justly designated the farmers' colleges. No truer title was ever conferred. I will only add that the strongest lever to raise and uphold the work of superior agricultural education represented by our system of agricultural colleges and experiment stations is to be found in this institute and kindred work.

BUREAU OF ANIMAL INDUSTRY

The work of the bureau in the control and eradication of contagious pleuro-pneumonia has been vigorous, and I am happy to state successfully prosecuted. Thanks to these vigorous measures, the contagion has not spread to any new districts, and the infected territory has been so steadily reduced in extent that it is now entirely confined to the following mentioned States. In New York the disease has been eradicated from Orange and New York Counties, and to-day is only found in Kings and Queens Counties, and is there much less prevalent than it was a year ago. The reports from New Jersey indicate that the disease has been practically stamped out, and there is every reason to believe that a few months of supervision will remove the last trace of the contagion. Only two small outbreaks have been reported from Pennsylvania within the past year. The first was effectually stamped out and measures promptly taken on receipt of the report of the second by the State veterinarian, and the slaughter of two affected animals seems to have removed all apprehension of further danger. But three affected herds have been found in Maryland the past six months, and there seems to be no likelihood of further trouble there. My intention is to maintain a sufficient force of inspectors in each of these States to establish a strict supervision of cattle for three or four months after the last appearance of the disease, thus insuring against any subsequent development of it. It is gratifying to recall that the effectual measures taken by this Department have almost entirely prevented the periodical rumors and subsequent panics among those engaged in the cattle trade which a few years ago were so frequent and so disastrous to the cattle industry.

The number of cattle purchased for slaughter from July 1, 1888, to June 30, 1889, in order to secure the eradication of the plague, has been: In New York, 1,460 diseased, 3,011 exposed; in New Jersey, 255 diseased and 880 exposed; in Pennsylvania, 15 diseased, 68 exposed; and in Maryland, 217 diseased, 624 exposed.

The number purchased per month gradually decreased until it became much less than during corresponding periods of the preceding year. The total number of cattle found affected during the last-

mentioned period with pleuro-pneumonia on *post-mortem* examination was: In New York, 1,561; in New Jersey, 302; in Pennsylvania, 29; in Maryland, 242; a total of 2,134. Reports received since June 30, 1889, indicate, as I have said, that the vigorous measures adopted have proved very effectual, and justify the most sanguine hopes in regard to the present control and proximate complete eradication of the disease.

The large number of cases of the malignant disease disseminated by Southern cattle, known as Texas or splenetic fever, led me to make regulations requiring special pens to be set apart in the leading stock-yards for the dangerous cattle; also providing for the cleaning and disinfection of the cars which had transported them. This has greatly reduced the losses, and when the regulations are perfected and thoroughly carried out the disease should be almost entirely prevented. With this malady the infection is generally spread through the channels of interstate commerce, and for that reason can only be effectually controlled by the Federal Government. For the protection of our citizens who purchase cattle in the great markets of the country, no less than for the reputation of the dressed beef which has become such an important factor in our domestic and foreign trade, the legislation relating to this subject should be ample and clearly defined.

MEAT INSPECTION.

Rumors of cattle diseases in this country having little foundation, if any, in fact, continue to be widely circulated in foreign countries to the great injury of our cattle trade. The existence of a demand for our surplus meat products in these countries is nevertheless plainly evident, and it is in the highest degree desirable that the Government of this country should adopt all means in its power to secure for our producers every opportunity to compete on fair terms in the markets of the world for the disposal of their surplus production. I would therefore insist most strongly upon the necessity of such a national inspection of cattle at the time of slaughter as would not only secure the condemnation of carcasses unfit for food, if there be any, and guaranty the accepted product as untainted by disease, but which should enable the national authorities to promptly discover any cattle-disease centers, thus putting it in the power of the Department to take immediate steps for its control and eradication.

While earnestly repudiating the captious objections made on the part of foreign authorities to the wholesomeness of our meat products, still, as long as we neglect to take the precautions universally adopted by the governments of those countries in which we seek a market for these products, and leave it to the officials of other countries to inspect our live cattle or our meats, it is impossible for us to present as forcible arguments as we could otherwise do against restrictions on our trade, these foreign governments claiming, with

some show of reason, that they have better opportunities for learning of disease among American cattle than are enjoyed by the American Government itself. It is time to put a stop to this anomalous condition, and I therefore earnestly recommend such an amendment to the law under which the bureau is at present organized as will provide for such official national inspection as shall guaranty the fitness of our meat products for food consumption under the seal of the United States Government.

In connection with such amendment, I would also suggest that it be made adequate to cover such an observation in, and supervision of, the great meat markets of this country as will permit this Department to supply to the stock-raisers of this country reliable information as to the character of stock commanding the highest prices. I conceive it to be of the greatest practical value to stock-raisers and farmers to know definitely what are the precise attributes which procure a price for certain kinds of stock far above the average, and whether the effect of such characteristics as weight, age, and quality, etc., upon the price, vary with different seasons of the year. In a word, I desire that the Bureau of Animal Industry be enabled to supply to the farmers such information relating to their industry as it is impossible for them to obtain by their own unaided efforts.

The investigations of the bureau have been the means of determining the nature and proper treatment of many outbreaks of disease among our domesticated animals which would otherwise have excited great alarm and led to heavy losses. The scientific researches, though they have accomplished much, are not yet by any means complete, and should be continued and extended till the field is thoroughly covered. The laboratory facilities of the Department are utterly inadequate for conducting this work according to the exacting requirements of modern science. Some diseases are communicable to mankind and can not be investigated because the laboratories are not sufficiently isolated from the remainder of the building, where many persons are employed.

DISEASE EXPERIMENT STATION.

The experimental station now established on rented ground requires enlargement and extension and all the facilities that science can provide for the effectual prosecution of this most important work, which means the saving of many millions of dollars annually to the producers of this country. I would propose, therefore, that 300 acres of the Arlington estate should be set aside for the use of this Department. This land is now unemployed, and being the property of the Government should be made available without further expense than that of removing to it the plant and equipment of the present station. I wish to earnestly insist upon the fact that foreign countries furnishing the most formidable competition in the markets of

the world to our American producers have adopted the most approved means which science affords to secure for their products an immunity which will procure for them the confidence of purchasers the world over. In work of this kind the United States Government must not be behind any other; indeed, in view of the importance of the interests involved, and American determination to be ever in the van, this country ought to lead all others in the prosecution of the work I have indicated.

To meet the many demands for more information in regard to animal diseases, a series of works are now in preparation giving a systematic statement of the current knowledge on the subject, prepared in popular form. Such publications, if properly revised and re-issued from time to time, so that they may give the latest attainable information, will be of permanent and increasing value.

In addition to its other duties, the bureau has had charge of the quarantine stations of the country. I have made certain needed improvements at some of the stations in order to better provide for the comfort and care of imported cattle while in quarantine. The stations have been successfully maintained and no case of disease has been introduced into the country during the year.

The work of the bureau as a whole has been of great value, but it has been too restricted in its nature, and it should be extended so that all the different branches of the animal industry would be properly represented in the investigations; and this naturally leads me to a consideration of

THE DAIRY INTERESTS.

The dairy interest is attaining very large prominence in American agriculture. Between 1850 and 1880 the census aggregates of cows on farms increased from 6,000,000 to 12,000,000, and the last estimates of this Department exceeded 15,000,000, including those in towns or villages, and the grand aggregate must exceed 16,000,000. The last census reported a butter product of 806,682,071 pounds. It was not less than 900,000,000 pounds, inclusive of cows not on farms. If the increase has been equal to the increment of population, the present aggregate can not be much less than 1,300,000,000 pounds. The cheese product may approximate 400,000,000 pounds, of which a goodly portion is exported, but the exports of butter have been small in amount and poor in quality.

I propose to establish in the Bureau of Animal Industry a special division devoted exclusively to the service of this great dairy interest. Dairying, when properly conducted, is unquestionably a most profitable branch of farming. The fact, also, that it supplies our people with one of the most complete and healthful of all foods gives it another claim to our consideration. Such products as butter and cheese are admirably adapted for transportation to distant markets,

permitting, as they do, a remarkable concentration of bulk in proportion to value, and taking but little from the fertility of the soil utilized in their production. A car-load of butter can be transported with comparatively little more expense than a car-load of steers, although the first represents five or six times the value of the latter. Foreign dairymen find profitable markets for their surplus product in Great Britain and in South America, and that fact suggests a similar opportunity for our American dairymen, emphasized by the recent award at Paris of a gold medal to American butter.

In an effort, however, to extend our butter and cheese trade in foreign markets, I wish to insist on the fact that absolute purity must be maintained and that the tastes of the foreign consumers must be consulted, not only as to keeping qualities and flavor, but also as to form or package and color. To enable our dairymen to succeed in this they must be informed as to these peculiarities of foreign taste, and such information this Department should be enabled, with the assistance of our consular service, to supply. The existence of a steady home demand for the superior grades of butter indicates that in this industry there is no danger of overloading the market. The extraordinary improvements introduced of late years into the process of butter-making merit a closer scrutiny and observation than the individual farmer and dairyman can afford to give, and which it should be within the province of this Department to undertake for his benefit. The plans I have formed for the encouragement of our butter interest imperatively demand the establishment of such a special division devoted to this subject.

POULTRY.

The time has come when the importance of the poultry interests should be recognized in this Department. The poultry products of the United States had a farm value of at least $200,000,000 last year, and no less than 16,000,000 dozen eggs were imported at a first cost of over 15 cents per dozen, or nearly $2,500,000, while the average annual value of such importation during the past four years has been $2,216,326. Such facts emphasize the necessity for encouraging the increase of domestic fowls of all kinds, and they further indicate beyond question that this industry is important enough to demand the special consideration of this Department.

The economics of rearing and feeding, the peculiar adaptation of the breeds to specific uses, merit more official attention than has heretofore been given to these subjects.

SHEEP AND WOOL.

The importance of sheep-husbandry demands the especial consideration of the Department at this time. The economics of breeding and feeding, with reference to a growing branch of the meat

supply, requires the aid of scientific experiment and practical skill to produce the largest equivalent of flesh for the feed consumed.

The rapid increase and consumption of mutton is indicated by an enlargement of the receipt of sheep at Chicago and St. Louis from 544,627 in 1875 to 1,971,683 in 1888. The increase in New York during the same period amounts to 750,000.

A canvass of the principal cities of the country would evidently show that consumption has doubled, a rate of increase twice as rapid as the advance of population. The healthfulness of mutton, its suitability for summer use in warm climates, and its growing popularity as highly fed animals of the best mutton breeds become more common in our markets, contribute to the rapidly enlarging demand. It is important that this branch of sheep raising should receive greater attention.

The wool industry probably represents $300,000,000 per annum, and the native wool product is four times as large as in 1860, while the average fleece weighs as much as two of that date. Prior to that time there was a slow increase of numbers and small advances in quality or weight. Large classes of goods which could not be produced in this country, as was claimed by importers and half believed by consumers, are now produced here in nearly full supply of the home demand. Their manufacture was rendered possible first by the effect of the war premium on gold and afterwards by the influence of the tariff of 1867.

The result of this development has been that growers have received hundreds of millions of dollars which would otherwise have gone to the Argentine Republic, Australia, and other countries. It has created a reliable supply of home-grown raw material for our manufactures and an evener and better quality of wool than that handled by nations depending on the growth of all climates, a better average quality of goods than those of foreign manufacturers, and a steady reduction of price through competition.

I respectfully call your attention to a fact full of significance in this connection. There has recently been serious interruption to the prosperity of wool-growers. Since the reduction of the tariff in 1883 the numbers of sheep have apparently been reduced about seven millions, and the importation of wool has increased from 78,350,651 pounds in 1884 to 126,487,729 the past year. Upon the sheep and wool industry of this country the burden of that loss has fallen, while our manufacturers have contributed so much additional money to foreign markets. Wool-growers are despondent in view of low prices of wool, and their interests are threatened in consequence.

On behalf this industry I commend these facts to you, and should they be submitted to Congress I ask for them intelligent and careful consideration.

It is to be assumed that when Congress, in its wisdom, raised this Department to its present dignity, and made its chief a Cabinet officer, the intention of our law-makers was not simply to add the luster of official dignity to an industry already dignified by the labor of its votaries, but to give it added influence and power for good in their behalf. It will not be amiss, then, if here and now I venture to offer some facts no doubt already familiar to you, but which strikingly emphasize the vast aggregate importance of the interests which it is the primary object of this Department to serve.

As far back as 1880 the value of the farms of the United States exceeded ten thousand million dollars. To the unremitting industry of their owners these farms yielded an aggregate annual value of nearly four thousand million dollars, in the production of which a vast population of nearly eight million of toilers utilized nearly half a billion worth of farm implements. The value of live-stock on farms, estimated in the last census to be worth over one thousand five hundred millions of dollars, is shown by the reliable statistics collected by this Department to be worth to-day two thousand five hundred and seven million dollars. A low estimate of the number of farmers and farm laborers employed on our five million farms places it at nearly ten million persons, representing thirty million people, or nearly one-half of our present population.

These few figures are surely enough in themselves to convince every thoughtful man of the responsibilities thrown upon the Department of Agriculture, but even they do not permit of a realization of their full portent, unless the correlation of agriculture with the other industries of this country be properly considered. It may be broadly stated that upon the productiveness of our agriculture and the prosperity of our farmers the entire wealth and prosperity of the whole nation depend. The trade and commerce of this vast country of which we so proudly boast, the great transportation facilities so greatly developed during the past quarter of a century, are all possible only because the underlying industry of them all, agriculture, has called them into being. Even the product of our mines is only valuable because of the commerce and the wealth created by our agriculture. These are strong assertions, but they are assertions fully justified by the facts and recognized the world over by the highest authorities in political economy.

No wonder, then, that I appeal earnestly and confidently for such support as will enable me to acquit myself creditably in the position to which your confidence has assigned me, and to see to it that the great work confided to me is efficiently performed. Throughout the country from time to time, and at all times in some parts of this great country, we find agriculture suffering from depression, to diagnose the cause of which is oftentimes a difficult task for our publicists and political economists, while our law-makers, both State

and national, find their most difficult task in the delicate duty of so adjusting the respective rights of every class of our citizens as to secure to each the full benefits of their industry. This is neither the time nor place to analyze causes of agricultural depression nor to discuss at length the many panaceas proposed for its relief, but I do feel that the agencies which already exist primarily for the benefit of the industrial classes must be extended to the full for the advantage of the tiller of the soil.

Protection of American industries is one of the rock-rooted principles of the great party which this administration represents. To all the protection that wise tariff laws can afford, and to the fullest extent compatible with the equal rights of all classes, which is a fundamental principle of republican institutions, the farming industry justly claims its inalienable right. In the diversification of agriculture which, I am thankful to say, has taken place during the past few years, and which I hope it will be in my power to greatly encourage, the farmer has been enabled to produce many articles comparatively unknown as a home product twenty years ago. For all such articles as our own soil can produce the farmer justly asks that protection which will insure to him all the benefits of our home market.

Another agency looking to the important well-being of the farmer is that which was called into being by the creation of this Department, an agency which, energetically and judiciously directed, will not fail of its purpose. Great as are our crops in the aggregate, it must be admitted that our broad acres are not as prolific as they should be, and I am convinced that, with the aid that can be afforded to agriculture by carrying out to the full the purposes for which this Department exists, and thanks to the rapid growth of intelligence and the remarkable efforts at self-help among our farmers, the yield of every tillable acre in this country can be increased 50 per cent. More than this will science, properly directed, enable us to accomplish, for millions of acres at present unproductive can, by its application, be rendered fertile. The great nations of Europe strain every effort to make science the hand-maid of war; let it be the glory of the great American people to make science the hand-maid of agriculture.

Such is the history of the year's operations of this Department, and such the condition and needs of the interests committed to its charge. I conclude this report with the expression of my thanks for the hearty co-operation and faithful service which the officers, clerks, employés, and correspondents of the Department have at all times given me.

Very respectfully, your obedient servant,

J. M. RUSK,
Secretary.

SPECIAL REPORT OF THE ASSISTANT SECRETARY.

TEXTILE FIBER PRODUCTION.

SIR: Inasmuch as my personal attention has been devoted to the measures undertaken during the past year with a view to collecting all available information, both at home and abroad, bearing upon textile fiber production, and inasmuch as this work is in charge of a special agent, Mr. Charles Richards Dodge, appointed by you especially for this purpose and reporting directly to myself, I therefore have the honor to submit to you a brief report, indicating what has been done during the current year with a view to supplying, by this Department, the fullest information obtainable on this important subject.

The interest in textile fiber production in the United States is increasing, as is attested by the large correspondence of the Department upon the subject. The many inquiries that are made relate not only to hemp, flax, ramie, and jute, but to a wide range of uncultivated fiber-producing plants, either of fixed commercial value and grown in other countries or those indigenous to the soil, which might through their culture become sources of wealth to the rural classes North and South.

The results of the investigations in Europe made in the past summer and fall by the special agent of the Department are most satisfactory, and a valuable fund of information regarding the foreign methods of culture with well-known, or progress with new, fibers has been secured, which in due time will be given to the public. This relates in the first place to flax and hemp cultivation and methods of handling in countries where the best results have been obtained, with latest information regarding machinery. It also includes a study of the ramie question, with a report on the ramie machine trials of 1889, held in connection with the Paris Exposition, and therefore official.

An investigation has been entered upon in this country having for its object, first, the securing of accurate information and statistics, as far as possible, upon every phase of fiber production, to establish the present status of these industries in the United States from the agricultural stand-point; secondly, to ascertain by what means and to what extent the production of well-known commercial fibers

may be increased with ample recompense to those engaged in agriculture, and how a profitable cultivation and utilization of new fiber plants may be most readily assured.

The production of hemp and flax in the United States is an industry which dates back to the earliest history of our country. The systems in the utilization of these products in manufacture have greatly changed in comparatively recent years. This fact, in connection with the importation of large quantities of several fibers grown in other countries, some of which are obtainable at low cost, is largely responsible for the great falling off in national production in the past thirty years. But what our people have done can be done again, and improved upon, though necessarily under new conditions modified to meet the requirements of the present times. The economy of labor, through a more intelligent understanding of the best methods of practice, together with the use of labor-saving machinery and the application of that energy for which the American people are noted, will go far to overcome differences in the value of labor here and in other countries.

Hemp culture, if only for the manufacture of binder twine, should be largely extended. The Department is already in possession of interesting facts regarding its production at comparatively low cost, and of its possible extension in certain directions in 1890. The vast stacks of straw derived from a million acres of flax grown for seed alone, in States from Ohio to Dakota, and burned or otherwise wasted, should be turned to valuable account in the farm economy. With somewhat better methods of soil preparation, with the planting of imported seed and more careful handling after the straw is grown, it is believed that flax can be cultivated both for seed and for a grade of fiber that would have a certain value for use in the coarser productions of manufacture, and thus make it a marketable commodity. An interesting inquiry in this direction has been instituted, which at the outset promises good results.

The vexed question of the establishment of the ramie industry, while more favorable to ultimate success than at any previous time, is yet beset with difficulties; machinery has been produced in both hemispheres concerning which we may record quite satisfactory performances in regard to the mere production of "ribbons" or of "filasse" of good quality, but in the consideration of quantity and ability for continuous operation something remains to be desired. Recent discoveries in this country in degumming the fiber of ramie, and in one branch of ramie spinning—on woolen and cotton machinery from carded fiber—are cheering indications of a future for the industry, from the manufacturers' point of view, in this country, when difficulties in the earlier preparation of the fiber shall have been fully overcome. Regarding the culture of jute I may say the same as has been said of ramie. There is no doubt but that the

Southern farmer can produce it profitably when the question of machine decorticators has been settled.

The consumption of sisal hemp in this country is enormous. Sisal can be grown (is grown in limited patches) in extreme southern portions of the country, and will produce fiber of good length and quality, several recent samples from Florida being in possession of the Department. Besides sisal there are several allied fiber plants which can be utilized if desirable, and which are commercial products in other countries.

Attention has also been called to okra and other fibrous plants of the Mallow family, all of which possess a certain value in industrial economy, and which could be produced in quantity, with ramie and jute, if their cultivation were desirable. It is my aim to obtain as full information regarding all of these fibers as possible, so that if the Department should at a future time institute experiments looking toward their utilization it may be well equipped for this purpose.

While I would encourage and recommend limited experiment with the culture of these new fibers in the South for the useful experience and the knowledge it will give, caution is nevertheless urged—considering that the industry has not yet been established on a satisfactory basis—against farmers going deeply into their culture in the hope of immediate large profits. For those who have kept pace with the development of the ramie question and, so to speak, have their eyes open, these suggestions are not made, but rather for the benefit of that other, larger class, whose only knowledge of the subject is gleaned from the extremely favorable report of the profitableness of these industries, made by interested parties.

The report now being prepared is well under way and will, it is hoped, be ready for distribution early in 1890. The intention is that it shall be as comprehensive of all information obtainable up to this date on this important subject as its limits will permit.

I respectfully submit the above.

EDWIN WILLITS,
Assistant Secretary.

Hon. J. M. RUSK,
Secretary of Agriculture.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a brief statement of the more important work accomplished by the Bureau of Animal Industry during the year 1889. For many interesting details of the work, and for the reports of agents, inspectors, and other employés, I must refer you to the Sixth Annual Report of the Bureau of Animal Industry.

Very respectfully,

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. J. M. RUSK,
Secretary of Agriculture.

PLEURO-PNEUMONIA.

The measures for the eradication of the contagious pleuro-pneumonia of cattle, as given in detail in former reports, have been continued during the year without interruption or modification. The progress of the work has been notable, though not as rapid as would be possible if the Department had sufficient authority to properly enforce its regulations. It has often been found difficult to secure the prosecution and conviction of parties who have violated the State laws under which the regulations are made. Some parties, who have flagrantly and persistently violated the regulations and even assaulted the officers of the Department, have had their cases dismissed by justices of the peace or by the grand juries before which the matter was brought, with the intimation that prosecutions for such offenses would not be countenanced by them.

The great obstacle to the speedy conclusion of this work is, therefore, not in any inherent difficulties in the work itself, but in the impossibility of securing under the present statutes a strict enforcement of the necessary rules. The infected area is, however, constantly decreasing, and the number of herds in which the disease is found is becoming smaller with each quarter. This improvement will be made plain in the tables which follow.

It is gratifying to be able to state that no outbreaks of pleuro-pneumonia have been discovered during the year in the section of the country west of the Alleghany Mountains. It is also fortunate that no extensions of the contagion have occurred in the Eastern States since the report for 1888 was submitted. The absence of such outbreaks has so increased the confidence of cattle-owners and shippers that our domestic traffic in cattle outside of the infected districts is no longer influenced to any appreciable extent by the presence of this contagion in the country.

WORK IN NEW YORK.

One year ago pleuro-pneumonia existed in the counties of Orange, New York, Kings, and Queens. No cases have been discovered in Orange and New York Counties since June, so that the disease has been confined for the last five months to Kings and Queens Counties. These two counties have long been the oldest and worst infected sections of the country. Many of the dairymen are unfavorably disposed towards the work of eradication and are unwilling to submit to the regulations. Cattle in many instances have been pastured upon the commons and moved from stable to stable without permit. Exposure in this way accounts for many of the new cases of disease which have been recently developed.

Many stables in the infected districts are without ventilation. They are so constructed that it is impossible to keep them in a proper sanitary condition. There are accumulations of filth under the floors, and the wood-work is rotten and porous. Such buildings can not be satisfactorily disinfected, nor can they be held without stock a sufficient length of time after the diseased herds are removed to insure safety. The result is that in some cases the plague has appeared several times on the same premises.

To prevent these re-infections is one of the most difficult problems which is to be solved. In Maryland there was for a time the same difficulty, and it was removed in the worst cases by the State Live-Stock Sanitary Board condemning and destroying such buildings as could not be properly disinfected. The compensation in such cases was made from the State appropriation. This Department has up to the present declined to expend any part of the appropriation for the purchase and destruction of buildings, but in certain cases in the badly infected districts of Long Island such action may become necessary for the success of the work.

From December 1, 1888, the date to which the figures were given in the previous report, to November 30, 1889, there were inspected in New York 15,861 herds, containing 149,396 head of cattle. Of this number 137,688 were re-examined by the non-professional assistants, and 33,135 were tagged with numbers and registered upon the books of the Bureau.

There were 156 new herds found affected with pleuro-pneumonia during the year, and these herds contained 3,014 animals, 249 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 1,053 affected cattle, at a cost of $28,210.05, an average of $26.79; also, 2,819 exposed cattle, at a cost of $59,908.93, an average of $21.25. The smaller cost of the exposed cattle as compared with the affected ones is due to the fact that the amount which the owner realized for the carcasses was deducted from the appraised value, the Department paying the balance.

It has been found necessary to disinfect 339 stables, stock-yards, or other premises during the year, and also to make *post-mortem* examinations upon the carcasses of 15,375 bovine animals, of which 1,012 were found diseased with pleuro-pneumonia.

The total expenses in New York from December 1, 1888, to November 30, 1889, have been $187,814.99, of which $88,118.98 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the expense for disinfection, inspection, tagging, registering, supervising the movement of cattle, *post-mortem*

examinations, and all the various expenses incident to a work of this character.

WORK IN NEW JERSEY.

In this State the operations have been almost entirely confined to Hudson County, with the exception of a large diseased herd found in the distillery stables at East Millstone, and three affected herds in Essex County which were infected by cattle taken by dealers from Hudson County in violation of the quarantine regulations.

The State Board of Health has for more than six months been desirous of removing the quarantine restrictions from Hudson County, but has consented to maintain them up to the present time upon the urgent representations of this Department that such action was necessary to the success of the work. It is doubtful if proper regulations can be continued in New Jersey under the present system of co-operation until the contagion is completely eradicated. The importance of success here is exceptionally great because of the traffic in cattle between the infected district in New Jersey and the neighboring counties in New York. If the disease should again become prevalent in the former State it would be difficult if not impossible to prevent the re-infection of Westchester and New York Counties in the latter State. There would also be great danger of the infection of cattle destined for shipment to Europe from the port of New York, many of which go through the New Jersey stock-yards. To properly protect this enormous trade between the States and with foreign countries greater powers are required than are now possessed by this Department.

From December 1, 1888, to November 30, 1889, there were inspected in New Jersey 8,455 herds, containing 76,001 head of cattle. Of this number, 39,287 were re-examined by the non-professional assistants, 11,672 were tagged with numbers and registered upon the books of the Bureau.

There were 48 new herds found infected with pleuro-pneumonia during the year, and these herds contained 964 animals, 81 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 116 affected cattle at a cost of $2,659, an average of $22.92 per head; also 704 exposed cattle at a cost of $16,592, an average of $23.57.

It has been found necessary to disinfect 208 stables, stock-yards, and other premises, and also to make *post-mortem* examinations upon the carcasses of 14,242 bovine animals, of which 189 were found diseased with pleuro-pneumonia.

The total expenses in New Jersey from December 1, 1888, to November 30, 1889, have been $69,345.42, of which $19,251 was paid for cattle purchased for slaughter, because they were either diseased or had been exposed.

THE WORK IN PENNSYLVANIA.

As indicated in the last report, quarantine restrictions at Philadelphia were removed on December 15, 1888, and at that time the greater part of the force of the Bureau stationed there was withdrawn. It was deemed advisable, however, to retain at that city two veterinary inspectors and two assistant inspectors for the purpose of maintaining a supervision of the Philadelphia stock-yards, and to watch the slaughter-houses and rendering works for a few months, in order that any re-appearance of disease might be

promptly detected. The wisdom of this course was made apparent on December 31, when our inspectors discovered at the Philadelphia stock-yards a herd of cattle having contagious pleuro-pneumonia. These cattle had been shipped to Philadelphia from the Somerset Distillery stables at East Millstone, New Jersey. On being slaughtered, seventeen cases of contagious pleuro-pneumonia were found on *post-mortem* examination. All cattle that had come in contact with this herd were promptly quarantined and slaughtered, and the stock-yards were thoroughly disinfected. The railroad cars in which these cattle had been transported were traced to Altoona, Pa., where they were disinfected by officers of the Bureau.

Under date of September 11, the Secretary of the State Board of Agriculture informed this Bureau that a herd had been discovered by the State officers in Chester County, Pa., having contagious pleuro-pneumonia, that the State veterinarian had killed two animals, and on *post-mortem* examination had pronounced them to be affected with contagious pleuro-pneumonia in an acute form. An officer of the Bureau was detailed to visit that locality but failed to find any evidence of lung plague among animals there inspected. For the reason, however, that the premises on which the disease had been reported to exist was a public cattle or drove yard from which cattle were transported to Wilmington, Del., the stock-yards at Philadelphia, and into other channels of interstate commerce, it was thought necessary, in order to protect the cattle industry of the country from any possible danger, that these premises, and also all cattle that had been in contact with the herd reported to have been diseased, should be strictly quarantined. This was done; and in addition the stock-yards at Chester, where the disease was said to be, were thoroughly disinfected. The quarantine was maintained for ninety days, and at the end of that time, no evidence of lung plague having developed, all restrictions were removed.

With these exceptions no contagious pleuro-pneumonia has been found in Pennsylvania during the year, and it is thought that the contagion no longer exists there.

From December 1, 1888, to November 30, 1889, there were inspected in Pennsylvania 1,311 herds, containing 24,003 head of cattle. Of this number 1,285 were re-examined by the non-professional assistants, and 1,513 were tagged with numbers and registered upon the books of the bureau.

There were no herds in the State found by our inspectors to be affected with pleuro-pneumonia. There were purchased for slaughter eleven exposed cattle at a cost of $190, an average of $17.27 per head.

It was considered advisable to disinfect six stables, stock-yards, and other premises; 13,412 *post-mortem* examinations were made upon the carcasses of bovine animals, of which 17 were found diseased with pleuro-pneumonia.

The total expenses in Pennsylvania from December 1, 1888, to November 30, 1889, have been $8,856.25, of which $190 was paid for exposed cattle purchased for slaughter.

WORK IN MARYLAND.

The progress of the work in Maryland has been extremely satisfactory. With the active sympathy of the Governor and Attorney-General, and the earnest co-operation of the Live-Stock Sanitary Board, the quarantine regulations have been enforced and the contagion has been eradicated. Only five herds affected with pleuro-

pneumonia have been discovered in the last ten months, and at this writing (December 20) three months have elapsed since a case of the disease has occurred.

We have here one of the most striking illustrations that the history of the world has furnished of the possibility of exterminating this plague from the worst infected of cities, and from the dairies of the adjoining country districts, within a reasonable time, by the application of proper sanitary measures. In the Old World it has always required many years under the regulations generally adopted to free a long infected district from the disease, while in some cities, as for example Paris, the work has gone on for years without appreciably diminishing the number of cases of disease which annually develop.

From December 1, 1888, to November 30, 1889, there were inspected in Maryland 10,904 herds, containing 79,606 head of cattle. Of this number 4,866 were re-examined by the non-professional assistants, and 10,534 were tagged with numbers and registered upon the books of the Bureau.

There were 18 new herds found infected with pleuro-pneumonia during the year, and these herds contained 295 animals, 21 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 72 affected cattle at a cost of $2,254.27, an average of $31.31 per head; also 311 exposed cattle at a cost of $7,341.83, an average of $23.61 per head.

It has been found necessary to disinfect 35 stables, stock-yards, and other premises during the year, and also to make *post-mortem* examinations upon the carcasses of 11,496 bovine animals, of which 76 were found diseased with pleuro-pneumonia.

The total expenses in Maryland from December 1, 1888, to November 30, 1889, have been $57,488.96, of which $9,596.10 was paid for cattle purchased for slaughter as either diseased or exposed.

THE WORK AS A WHOLE.

Including all the districts in which pleuro-pneumonia has existed, there were inspected from December 1, 1888, to November 30, 1889, a total of 36,531 herds of cattle, containing 329,006 animals. Of this number 183,126 were re-examined by the non-professional assistants in addition to the veterinary inspections, and 56,854 were tagged with numbers and registered upon the books of the Bureau.

There were 222 new herds found affected with pleuro-pneumonia during the year, and these herds contained 4,273 animals, 351 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 1,241 affected cattle at a cost of $33,123.32, an average of $26.69 per head; also, 3,845 exposed cattle at a cost of $84,032.76, an average of $21.86 per head.

It has been found necessary to disinfect 588 stables, stock-yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 54,520 bovine animals, of which 1,294 were found diseased with pleuro-pneumonia.

The total expenses of the pleuro-pneumonia work from December 1, 1888, to November 30, 1889, have been $323,505.62, of which $117,156.08 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the expense for inspection, disinfection, tagging, registering, and supervising the movement of cattle, of *post-mortem* examinations, and of all the various expenses

necessary to insure the prompt discovery of this plague when it appears in any herd, and to prevent the further extension of the infection.

The following table gives a résumé of the pleuro-pneumonia work from December 1, 1888, to November 30, 1889, as given in detail above:

	New York.	New Jersey.	Pennsylvania.	Maryland.	Total.
Herds inspected	15,861	8,455	1,311	10,904	36,531
Cattle inspected	149,396	76,001	24,003	79,606	329,006
Cattle re-examined	137,683	39,287	1,285	4,866	183,126
Diseased cattle found by inspection	249	81	....	21	351
Post-mortem examinations	15,375	14,242	13,412	11,491	54,520
Diseased carcasses found	1,012	189	17	76	1,294
Cattle tagged	33,135	11,672	1,513	10,534	56,854
New herds found affected	156	48	....	18	222
Animals in affected herds	3,014	964	....	295	4,273
Diseased cattle purchased	1,053	116	....	72	1,241
Exposed cattle purchased	2,819	704	11	311	3,845
Premises disinfected	339	206	6	35	588

A résumé of the expenditures in the pleuro-pneumonia work from December 1, 1888, to November 30, 1889, is made in the table which follows:

	New York.	New Jersey.	Pennsylvania.	Maryland.	Total.
Salaries	$81,863.02	$36,600.58	$7,630.53	$37,712.99	$163,807.12
Traveling expenses	11,746.78	10,629.92	614.83	8,903.87	31,895.40
Miscellaneous expenses	6,086.21	2,863.92	420.89	1,276.00	10,647.02
Affected cattle	28,210.05	2,659.00	....	2,254.27	33,123.32
Exposed cattle	59,908.93	16,592.00	190.00	7,341.83	84,032.76
Average paid for affected cattle	26.79	22.92	....	31.31	26.69
Average paid for exposed cattle	21.25	23.57	17.27	23.61	21.86

COMPARISON WITH THE PREVIOUS YEAR.

The progress accomplished by this work can only be estimated by comparing the number of new herds found affected during the year and the total number of cases of pleuro-pneumonia found on *post-mortem* examination with similar data gathered from the reports of the preceding year. As the carcasses of all animals which die or are slaughtered from the quarantine districts are examined, we have in the returns of the *post-mortem* examinations the total number of cases of pleuro-pneumonia which have developed.

The following table shows the number of new herds found affected, the number of *post-mortem* examinations that were made, and the number of carcasses found affected with pleuro-pneumonia at the *post-mortem* examinations for the years from December 1, 1887, to November 30, 1888, and from December 1, 1888, to November 30, 1889:

States.	No. new herds affected.		No. of post-mortem examinations.		No. of carcasses affected with pleuro-pneumonia.	
	1888.	1889.	1888.	1889.	1888.	1889.
New York	347	156	15,826	15,375	2,374	1,012
New Jersey	216	48	6,892	14,242	536	189
Pennsylvania	23	....	13,157	13,412	72	17
Maryland	96	18	6,165	11,491	596	76
Total	682	222	42,040	54,520	3,578	1,294

The above table shows that there were less than half as many new herds found affected in New York during the last year as in the preceding year. There were also less than half as many diseased carcasses found on *post-mortem* examination in 1889 as in 1888, although the number of carcasses examined was nearly the same. In New Jersey there were only about one-fourth as many affected herds and about one-third as many affected animals, although a greatly increased number of carcasses was examined. In Pennsylvania and Maryland the reduction as shown by the table is even more marked, and is still greater than the figures indicate, as the malady has entirely disappeared from those States during the last quarter of the year.

REGULATIONS CONCERNING TEXAS FEVER.

The losses from the disease commonly known as Texas or splenetic fever have for many years been very heavy. Generally the affected animals are export cattle or steers purchased from stock-yards for fall and winter feeding. In both cases the disease is contracted from the stock-yards or from cars in which cattle from the infected district have been yarded or transported. Occasionally a few southern cattle are mixed with a larger number of northern animals and the whole bunch is sold for feeding. The result of this is that all the northern cattle exposed in this manner contract the malady and most of them die.

A disease which can be so easily prevented by providing separate pens for the susceptible and dangerous cattle, and by promptly cleaning the infected cars, should not be allowed to remain a standing menace to the feeders of the country and an incubus upon the foreign trade in live cattle. To correct this evil the following order was issued:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., July 3, 1889.

To the Managers and Agents of Railroad and Transportation Companies of the United States:

In accordance with section 7 of an act of Congress approved May 29, 1884, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," you are hereby notified that a contagious and infectious disease known as splenetic or Texas fever exists among cattle in the following described area of the United States:

All that country lying south and east of a line commencing at the northeasterly corner of the county of Crittenden, in the State of Arkansas, thence running in a northwesterly direction to the Osage Agency, in the Indian Territory, and thence running southwesterly to the Rio Grande River at the intersection of the southeasterly corner of Pecos County and the northeasterly corner of Presidio County, in the State of Texas.

No cattle are to be transported from said area to any portion of the United States north or west of the above described lines except in accordance with the following regulations:

First. On unloading north or west of this line any cattle in course of transportation to be fed and watered on the way, the places where said cattle are to be so fed and watered shall be set apart and no other cattle shall be admitted into said places. Once a week from the date hereof until the first day of December, 1889, these watering and feeding places shall be thoroughly cleansed and disinfected.

Second. On unloading said cattle at their points of destination the regulations relating to the movement of Texas cattle, prescribed by the cattle sanitary officer of the State where unloaded, shall be carefully observed. The cars that have carried said stock shall be cleansed and disinfected before they are again used to transport, store, or shelter animals.

The cars used to transport such animals and the pens in which they are fed and watered shall be disinfected in the following manner:

(*a*) Remove all litter and manure. This litter and manure may be disinfected by mixing with lime, diluted sulphuric or carbolic acid, or if not disinfected, it may be stored where no cattle can come in contact with it until after December 1.

(*b*) Wash the cars and the feeding and watering troughs with water until clean.

(*c*) Saturate the walls and floors of the cars and the fencing, troughs, and chutes of the pens with a solution made by dissolving four ounces of chloride of lime to each gallon of water.

The losses resulting yearly to the owners of northern cattle by the contraction of this disease from contact with southern cattle, and through infected cars, and by means of the manure carried in unclean cars from place to place, have become a matter of grave and serious concern to the cattle industry of the United States. It is necessary, therefore, that this cattle industry should be protected as far as it is possible by the adoption of methods of disinfection in order to prevent the dissemination of this disease.

A rigid compliance with the above regulations will insure comparative safety to northern cattle and render it unnecessary to adopt a more stringent regulation, such as the absolute prohibition of the movement of Texas cattle except for slaughter during the time of year that this disease is fatal.

Inspectors will be instructed to see that disinfection is properly done, and it is hoped that transportation companies will promptly put in operation the above methods.

Very respectfully,

J. M. RUSK,
Secretary.

The effect of this regulation was very marked, but some infected cars were apparently used between the stock-yards of the interior and the ports at which cattle are shipped, as a number of lots became affected on the voyage and heavy losses resulted. To guard against a recurrence of such cases another circular was sent to the managers and agents of railroad and other transportation companies as follows:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., August 10, 1889.

To the Managers and Agents of Railroad and Transportation Companies of the United States:

In addition to my order of July 3, 1889, in regard to cleaning and disinfecting cars and pens which have been occupied by cattle liable to disseminate splenetic or Texas fever, I desire to impress upon you the importance of special precautions to prevent the infection of cattle which have been selected for exportation. The number of cattle shipped to Europe has rapidly increased and the trade is probably more promising than ever before. This relieves our markets, gives new vigor to the cattle industry, and proportionally increases the business of transportation companies.

It is feared by shippers that some of these export cattle may become infected from cars which had carried southern cattle before the regulations of July 3, 1889, went into effect. A single shipment of animals thus affected might lead other countries to prohibit the entrance of our cattle and consequently ruin this trade, which is now of so much importance to the country. Not desiring at present to make a regulation requiring that *all* stock-cars should be cleaned and disinfected before cattle are loaded into them, I would earnestly request the managers of all transportation companies doing business between the interior and the sea-board to make provision whereby all cars, in which cattle for export are to be transported, shall be thoroughly cleaned and disinfected previous to loading, in accordance with the instructions contained in my order of July 3.

Arrangements have been made at New York by which one yard, accessible to all railroad companies, has been set apart exclusively for export cattle. I understand that one of the trunk lines between Chicago and New York has already at the request of shippers instructed its agents to furnish disinfected cars for such cattle, and I trust that all others will immediately give the export trade the benefit of similar precautions, thus avoiding the necessity for an extension of the order of July 3, to include all cars in which cattle are transported.

Very respectfully,

J. M. RUSK,
Secretary.

The regulations were removed on November 1, as the danger for the year was believed to be over at that time. The following circular was sent as a notification to interested parties:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., November 1, 1889.

To the Managers and Agents of Railroad and Transportation Companies of the United States:

The order of July 3, 1889, prescribing regulations for the transportation of Texas and other southern cattle, and for the isolation, cleaning, and disinfection of pens which have been occupied by such cattle, is hereby revoked. It is believed that the danger from splenetic or Texas fever has passed for the present year.

Very respectfully,

J. M. RUSK,
Secretary.

It is believed that by enforcing regulations similar to those contained in the order of July 3, from an earlier period of the year, this disease can be almost entirely prevented in all portions of the country except the permanently infected district.

GLANDERS.

No new regulations have been made during the year concerning the work for the suppression of glanders in the District of Columbia. A systematic inspection of all the horses in the District has not been attempted, but all reported and suspected cases have been investigated. While the disease has not been entirely eradicated, the results of the action so far taken is very marked and satisfactory. The discovery of a glandered horse on the streets of Washington, instead of being a common occurrence as it was formerly, has become very rare indeed. The number of horses killed during the year because affected with this disease was as follows:

1888: December, 13. 1889: January, 21; February, 1; March, 8; April, 18; May, 8; June, 1; July, 1; August, 1; September, 2; October, 2; November, 1. Total, 78.

UNITED STATES CATTLE QUARANTINE.

The superintendents of the various neat-cattle quarantine stations report the names of the importers and the number and breed of each lot of animals imported during the year 1889, as follows:

STATION FOR THE PORT OF NEW YORK, GARFIELD, N. J.

[Dr. Wm. Herbert Lowe, Superintendent.]

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. animals.
June 4	Hon. J. R. McPherson, Belle Meade, N. J.	Antwerp, Belgium	Holstein-Friesian	35
14	H. N. Heffner, Delaware, Ohio	London, England	Red Polled	11
28	Alfred Sully, New York, N. Y	do	Hereford	3
Aug. 29	E. N. Howell, Poughkeepsie, N. Y	do	Guernsey	11
Dec. 7	John H. Starin, New York, N. Y	Liverpool, England	Aberdeen-Angus	7

STATION FOR THE PORT OF BOSTON, LITTLETON, MASS.

[Dr. A. H. Rose, Superintendent.]

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. animals.
Jan. 21	Luther Adams, Boston, Mass	Liverpool, England	Sussex	2
			Aberdeen-Angus	3
			Short-horn	30
June 5	E. K. Stratton, Greensborough, Ind	do	Galloway	13
July 16	Hon. Edward Burnett, Southborough, Mass.	do	Guernsey	26

STATION FOR THE PORT OF BALTIMORE, ST. DENIS, MD.

[Dr. A. M. Farrington, Acting Veterinary Inspector.]

Date of arrival.	Name and post-office address of importer.	Port of shipment.	Name of breed.	No. animals.
June 24	Clark Maxwell, Winchester, Va	Liverpool, England	Galloway	11
Oct. 16	Christian Heurich, Washington, D.C.	Hamburg, Germany	Angler	14

The following shows the whole number of cattle received at the various stations from January 1, 1889, to January 1, 1890:

Garfield Station	67
Littleton Station	74
Patapsco Station	25
Total	166

No contagious disease appeared among the cattle at any of the stations during the year, and the general health of all the animals imported was good.

INOCULATION AS A PREVENTIVE OF SWINE DISEASES.

Inoculation with hog cholera virus was first tested as a preventive for this disease in the experiments of the Bureau of Animal Industry in the year 1886. The method of inoculation was discovered at that time, but the results were unsatisfactory, as the animals were not sufficiently protected, and the experiments have been repeated under various conditions from that time to the present to learn if any modification of the operation would make it more effectual.

Prevention by inoculation depends on the well-known principle that one attack of a contagious disease generally protects the individual from subsequent attacks of the same contagion. The amount of protection received varies greatly with different diseases and different animals. In no case are all individuals protected in this way from any disease, and in many cases the immunity lasts only for a short period of time.

Inoculation in practice consists in injecting under the skin as much of the strong virus of hog cholera as can be given without producing a fatal attack of the disease. Inoculation is very different from vaccination. The virus used in inoculation is the same in variety and strength as that found in animals dying with the plague, while for vaccination a weakened virus is used, which can not cause a fatal disease. No method of vaccination has yet been introduced for the hog diseases of this country. Inoculation is now being advocated as a preventive for hog cholera, and it should be remembered that this means the introduction into the animal's body

of the strong virus of the malady, and it is only a question of the size of the dose whether the disease produced by this operation is mild or fatal in its character.

The dose is not the only factor which influences the result that follows inoculation. The strength of the virus varies so much in different outbreaks of the same disease, that a perfectly harmless dose obtained from one outbreak would be certainly fatal when obtained from another.

There is another influence which has an even greater effect in varying the results of inoculation, and that is the wide difference in the susceptibility of the animals. A dose of virus that will scarcely affect one animal will kill another in the same herd, and there is also such a great difference in the susceptibility in different herds that the dose which might be used on one herd without producing any noticeable effects would set up a disease in another herd and cause the loss of a majority of the animals.

With these varying conditions, which in many cases can neither be foreseen nor controlled, inoculation is an operation which is attended with more or less danger of producing the very disease which we are seeking to avoid. In our experiments we found that a dose of 1 cubic centimeter, *i. e.*, from 15 to 20 drops, of the strongest cultivated virus would occasionally kill an animal. From one-quarter to one-half this quantity, *i. e.*, from 4 to 10 drops, have been given without serious consequences in any case.

Such doses generally produce a swelling where injected, which is at first warm and more or less painful, and later becomes encysted. The center softens, disintegrates and becomes a purulent mass, which may remain encysted or may force an opening through the skin and discharge for several weeks. An inoculation of this kind produces a slight degree of immunity, because a second inoculation can then be made with two or three cubic centimeters of virus, *i. e.*, with four to twelve times the first dose, and still no fatal effects result.

The second inoculation increases the immunity, but still the animals are not able to resist the effects of feeding with strong virus or exposure in pens where sick animals are kept. We inoculated about fifty animals in this way in our first experiments, varying the doses somewhat, and only five of them resisted the first exposure. By giving two inoculations we, of course, get a greater degree of protection than can possibly be obtained from one inoculation, with safety to the animals, but the expense of two inoculations is so great that, in order to make the method practical, the inoculator gives only one dose and generally increases that beyond the limit of safety. Thus, in some experiments that have been made in the West, I am informed that a dose of 1 cubic centimeter, *i. e.*, from 15 to 20 drops, was given, and many herds contracted the disease and died, as should have been anticipated from the experiments previously made by the Bureau of Animal Industry.

In view of these facts, when any one comes before the farmers of the country and recommends inoculation, it is well to inquire whether he is interested in the operation from a pecuniary point of view. The question as to how much the farmer will save by the adoption of this method of prevention is uncertain, and opens a wide field for discussion, but the sum it will be necessary for him to pay out to the experts who must be employed can be very accurately figured. This is one of the most practical aspects of the question and should under no circumstances be overlooked.

It has been asserted that as many as one hundred and four hogs have been inoculated in seventy-two minutes. At a cost of 50 cents a head, which is the amount now charged for inoculation, this would reach the sum of $43.33 an hour for the services of the inoculator, which certainly appears to be more than those engaged in the hog-raising industry can afford to pay for professional assistance.

Should inoculation be generally adopted in the States in which hog raising is most largely carried on, it would require at least fifty men working five hours a day to comply with the demands. These men, inoculating eighty hogs an hour each, would inoculate a total of twenty thousand hogs a day, which would yield a daily revenue of $10,000. The total cost of hiring fifty men and maintaining a laboratory to supply virus would hardly exceed $300 a day. Putting the expenses at the liberal sum of $500 a day, the net profit to those conducting the inoculations would be $9,500 a day. The inoculation of but a small portion of the hogs in the chief hog-raising States of the country would therefore yield a profit to the inoculator of about $3,000,000 per annum, a sum which is sufficient to account for many of the enthusiastic and exaggerated statements of the benefits to be derived from inoculation which have appeared in public prints.

It has been shown by our experiments and by those of other investigators, that if a sufficient dose of virus is given to produce any degree of immunity the hog will be more or less stunted, and if the strong virus is used there is great danger of infecting the ground. Now, these two faults are inherent in the method; they can not be avoided, and it is impossible to so improve the operation as to overcome them. About a year ago an attempt was made to demonstrate the success of inoculation by inoculating one thousand hogs belonging to farmers in Nebraska. There had been quite a controversy between parties in that State for more than a year as to the merits of the operation, and undoubtedly every precaution known to the operators was practiced to secure a successful issue for this experiment.

The director of these experiments afterwards reported in the Nebraska State Journal of December 16, 1888, that one party who had 260 hogs inoculated had lost 220. Another farmer who had 46 inoculated lost "nearly all." Still another who had 121 inoculated lost "a large number," while a fourth, who had 93 inoculated, lost "all but 18 or 20." It is evident from these statements that out of the 1,000 hogs inoculated, the loss was very little, if any, less than 400 head. The disease in these cases appeared in the inoculated herds from ten to fifteen days after the inoculation, and was evidently introduced in most if not in all cases by this operation.

These experiments show that inoculation is attended with very considerable danger to the health and lives of the animals operated upon. It is no doubt possible to so reduce the dose of the virus as to prevent this heavy mortality following the inoculation, but in that case the protection would be correspondingly less. Leaving out of consideration the question of whether the hog, in case he survives the inoculation, is protected from the disease, it is plain that an operation which is followed by four hundred deaths out of a thousand inoculations has not been sufficiently perfected to merit the confidence of the farmers.

We will now turn for a moment to the question of the protection by the operation. To what extent were the hogs inoculated in Nebraska protected from the contagion, if really exposed to it? The

advocates of inoculation tell us that it has been impossible for them to give the disease to their inoculated hogs. Our experiments at Washington show that nearly all inoculated hogs can be afterwards fatally infected with cholera. Did the animals inoculated in Nebraska receive any greater degree of immunity than those which were inoculated in Washington?

The Board of Inquiry appointed by the Commissioner of Agriculture in 1888 procured a number of hogs that had been inoculated in Nebraska (about seventeen), and tested them by feeding them with cultivated virus of hog cholera and by inoculating them with the virus of hog cholera and swine plague. In each case a number of the animals that had not received the protective inoculation were used in the experiments to determine the effect of exposure upon ordinary swine. The first test was made by feeding cultivated virus, but this did not prove strong enough to kill any of the hogs. Even those which had not been inoculated survived, but all of the hogs, including those that had been inoculated, were very sick. The inoculated hogs were not quite as sick as the others, but there was very little difference. Four of the inoculated hogs from Nebraska, and five hogs from Pennsylvania which had not previously been inoculated, were then inoculated with the virus of the disease known as infectious pneumonia or swine plague. Of the four Nebraska inoculated hogs, three died and one recovered, but this one when subsequently killed for examination proved to be very severely affected. Of the five hogs which had not been previously inoculated one died and four were sick and recovered. When killed for examination one of the four was found seriously diseased, the three others were either slightly or not at all affected.

Still later four Nebraska inoculated hogs and two other hogs which had not been inoculated were fed upon the viscera of hogs which had died of hog cholera. Two of the inoculated hogs and the two that had not been inoculated contracted hog cholera and died. Two of the inoculated hogs remained well.

As a last test, the remaining six animals from Nebraska were inoculated by intravenous injection of the cultivated virus of hog cholera. Of these, three had been inoculated with hog cholera virus, one had been inoculated with the sterilized liquids in which hog-cholera germs had grown, and two had recovered from an attack of hog cholera. The four hogs which had received the protective inoculation all died. One of the recovered hogs died and the other resisted the virus and remained well.

It is quite evident from these experiments that the animals inoculated in Nebraska were fully as susceptible to hog cholera after the operation as were those which had been inoculated in the experiments of this Bureau in Washington.

The conclusion that inoculation is not a satisfactory preventive for hog cholera is by no means inconsistent with the results obtained in investigating other diseases. Various experiments have shown that the protection which follows one attack of a disease or which is produced artificially by inoculation or vaccination is by no means absolute. It is simply an increased power to resist that particular contagion, and it may be sufficient to guard against the small doses of the virus which with most diseases are all that an animal is exposed to under ordinary conditions. But if from any cause a larger quantity of the contagion finds its way into the animal's body it will contract the disease in a fatal form in spite of the immunity derived

from a previous attack or from inoculation. This was strikingly shown in the writer's experiments with fowl cholera (Report Department of Agriculture, 1881–'82, p. 289) and by the researches of Professor Chauveau with anthrax. While therefore it may be perfectly practical to prevent by inoculation those diseases in which the contagion does not multiply outside of the body, and with which the attack is caused by a small quantity of virus floating in the air or adherent to the wood-work of buildings, it may be much more difficult or impossible to prevent that other class of diseases to which hog cholera belongs, and which are caused by germs that multiply freely in water, in the soil, and in moist organic matter, and which are consequently taken into the body in enormous quantities, especially by swine.

There is another very important consideration which bears upon the practicability of preventing swine diseases by inoculation. Hogs inoculated with hog cholera virus do not receive the slightest degree of protection from any other disease. As there are at least two contagious diseases of hogs in this country, both of which are widely scattered and fatal, we can not hope by any single inoculation to prevent all the losses caused by contagious diseases of swine. To inoculate for two diseases would double the expense, and this would be a very serious objection to such a method of prevention. The existence of two diseases has been very vigorously denied, but the conclusions of the Bureau of Animal Industry on this subject have now been confirmed not only by the Board of Inquiry appointed to consider this question, but also by Professor Welch, the eminent pathologist of Johns Hopkins University. In the future, therefore, the conclusions as to the economy of preventing swine diseases by inoculation must be based upon the assumption that there are at least two diseases, each of which will require a special inoculation for its prevention.

This brings us to the final test which must be applied to all methods of prevention, and that is their economic results. We will now consider inoculation from this point of view. Leaving out of consideration for the present the many reasons for believing that inoculation is a dangerous operation, and that it does not do what is claimed for it in the way of prevention, we will compare the cost of preventing hog cholera by this operation with the amount of the loss caused by this disease.

According to the estimates of the Statistical Division there are about 50,300,000 hogs in the United States. The inoculation of these at 50 cents per head would cost $25,150,000. The total loss from disease during the year 1888 was 3,105,000 hogs at an average value of $5.79 each. This would make the total loss of swine from all diseases $17,980,000. In order to estimate the loss from hog cholera we must deduct from this sum the losses from ordinary diseases, such as animal parasites, exposure, overcrowding, and improper feeding, which are always acting and do not produce epizoötic diseases. These losses were estimated by the Statistician of the Department in 1886 to be about 4 per cent. of the total number of hogs, but as this may be considered rather a large estimate, we will in our calculation take 3 per cent. as the average loss from such causes. This would amount in 1888 to 1,509,000 animals, valued at $8,737,000, and deducting this from the total loss of swine, we have remaining $9,243,000 as the losses from epizoötic swine diseases. In the present condition of our knowledge we must admit that there are at least two entirely distinct

epizoötic diseases of hogs, which have been referred to in the reports of this Bureau as hog cholera and swine plague. The exact proportion of the loss caused by each of these diseases is at present unknown, but if we admit for the purposes of this calculation that but one-third of the loss is caused by swine plague, we have remaining a loss of but $6,163,000 for the year 1888, which can be attributed to hog cholera. To prevent this disease by inoculation, as we have just seen, requires the expenditure in cash of $25,150,000, or more than four times the value of the actual losses. In addition to this expenditure there should be counted the time required of the farmer in handling the hogs at the time of the operation and in giving them such precautionary care, and in practicing such disinfection as is required to make this operation at all successful.

We should reach the same conclusion if, instead of estimating the loss and expense for the whole of the United States, we should take a single hog-raising State, as for example the State of Illinois. According to the Statistician's estimate, there are 5,275,000 hogs in Illinois, and to protect these by inoculation would cost $2,637,000. In the year 1888 the total losses of hogs in that State from all diseases was about 316,500, with an average value of $7.45 each, which would make the loss for that year $2,359,925. Deduct a loss of 3 per cent. of all the hogs in the State as caused by ordinary diseases, and we find that this would amount to 158,250 hogs, worth $1,178,962. Deducting the losses caused by ordinary diseases from the total losses from all diseases and we have $1,180,963 left to represent the loss from both hog cholera and swine plague. Take from this one-third to represent the loss from swine plague, and we have remaining as the loss from hog cholera about the sum of $800,000. To prevent this loss by inoculation, as we have seen, would require $2,637,000, or more than three times the sum to be saved.

While it is evident from these figures that inoculation can not be recommended for general adoption under the conditions in which the operation must now be performed, it is conceivable that there may be special cases in which it may be found advantageous, provided its protective power is fully demonstrated. At distillery establishments where large numbers of hogs are purchased for feeding, and where the losses are necessarily heavy from epizoötic diseases, inoculation might prove an economic measure, but before deciding this question it would be necessary to have more definite data in regard to the average loss in these establishments.

Again, inoculation might prove efficacious in cases where considerable numbers of hogs are purchased at a distance by farmers for feeding. In this case there are unusual opportunities for infection during transportation, and experience shows that the loss from epizoötic diseases is unusually heavy. Here also it would require considerable experience before it would be possible to say whether the operation would be a financial benefit.

The operation is also being tried by breeders of thoroughbred swine in some sections. In this case there are animals of much more than average value to be protected, and, at first sight, it would appear that an outlay of 50 cents per head might be afforded in case any immunity could be assured. It should be remembered, however, that in case there should be considerable losses from inoculation, this would be more severely felt with high-priced animals than with those of average value. Another consideration even more important appears

to have been overlooked. In inoculating a herd the contagion of the disease is introduced upon the premises, and in spite of any precautions which can be observed the grounds will be infected. This infection remains a considerable time, and the experience of those who have had herds inoculated is said to show that if any uninoculated hogs are added to the herd they are very liable to contract cholera and succumb to the disease. If this observation is correctly interpreted, it is apparent that hogs sold from such herds for breeding purposes are liable to convey the disease to the herds into which they are introduced. This being the case, no breeder could afford to have inoculation practiced on his herd, because none would buy from him knowing that there was danger of introducing a fatal disease with the animals purchased.

The considerations mentioned above, which our present information demonstrates to have a bearing upon the subject of inoculation, should be taken into account by swine breeders before the adoption of this operation. There are undoubtedly other arguments for and against inoculation which greater experience will bring out, but we can only form a reliable opinion of its availability by reasoning from the knowledge at hand, and this we have endeavored to set forth with as much detail as is practicable in a report of this character.

THE BEEF SUPPLY OF THE UNITED STATES AND THE LEADING CONDITIONS GOVERNING THE PRICE OF CATTLE.

The desire on the part of those interested in the production of beef cattle to obtain an approximate statement in regard to the number of cattle in the country and the relation of this number to the population for a series of years has led me to prepare an article on this subject for the report of this Bureau for 1887 and 1888. The delay in the publication of that volume, together with the fact that a year has passed since the article was prepared, makes it desirable that a brief statement should accompany this report, bringing down to the present the figures which were given at that time.

The estimated number of animals from which the beef supply is drawn gives but little idea as to whether this supply has increased more rapidly than the demands, or whether, on the other hand, it has diminished. Our rapidly increasing population and our fluctuating export trade must be constantly borne in mind, if we wish to hold clear views on this important subject.

There has been a feeling for a number of years that more accurate data should be obtained in regard to the number of the range cattle in the various States and Territories. It is probable that no accurate census of the range cattle has ever been secured, and nearly all the estimates, on account of the inherent difficulties of the case, have varied widely from each other, and probably from the true figures. In order to clear up this question somewhat, an effort was made during the year 1888 to obtain reliable data from the Western States and Territories. Accordingly, trusted agents of the Bureau, well acquainted with the range-cattle industry, were sent into the field to gather the most accurate figures possible from the cattle-owners' organizations and from other sources of information. The estimates of the Statistical Division of this Department have, as a rule, been taken as approximately correct for the number of cattle in the States, but in some cases these estimates have been revised in accordance with more recent information received from the agents of this Bureau. The

population since 1880 has been estimated on a basis of a 2 per cent. annual increase in addition to the immigration.

Taking our figures from these sources we obtain the following table:

Table showing population, total number of cattle, and number of cattle per 1,000 of population (estimated since 1880) in the United States and Territories.

Years.	Population.	Total cattle. Number.	Total cattle. Per 1,000 of population.	Years.	Population.	Total cattle. Number.	Total cattle. Per 1,000 of population.
1850	23,191,876	17,778,907	767	1884	56,955,487	44,800,674	787
1860	31,443,321	25,620,019	815	1885	58,489,943	46,794,256	800
1870	38,558,371	23,820,608	618	1886	59,993,945	47,612,283	794
1880	50,155,783	37,008,453	738	1887	61,683,933	48,308,623	783
1881	51,828,330	38,551,471	744	1888	63,464,501	48,923,880	771
1882	53,653,889	40,672,765	758	1889	65,172,405	49,417,101	758
1883	55,330,289	42,777,898	773				

This table shows some interesting facts. At the first approximately accurate census of cattle in 1850 there were 767 cattle to the 1,000 of population. This number increased in 1860 to 815, showing a large stock of cattle on hand at that time. In 1870, partly from the effects of the war, and partly from an underestimate of the number of cattle in the country by the census of that year, we find the number of cattle reduced to 618 per 1,000 of population. In 1880 the number per 1,000 increases to the extent of 120 and reaches 738. In 1881 there is an increase of 6 per 1,000; from 1881 to 1882 the increase is 14 per 1,000; from 1882 to 1883 it is 15 per 1,000, being the largest apparent increase in any one year; from 1883 to 1884 the increase is 14 per 1,000; and from 1884 to 1885 it is 13 per 1,000, reaching the highest point since 1860, or 800 cattle per 1,000 population.

Since 1885 there has been, according to these estimates, a steady decrease in the relative number of cattle. From 1885 to 1886 this was 6 per 1,000; from 1886 to 1887 it was 11 per 1,000; from 1887 to 1888 it was 12 per 1,000; and from 1888 to 1889 it was 13 per 1,000. The total decrease in cattle per 1,000 population from 1885 to 1889 amounted to 42, and the proportion was then as 758 to 1,000.

A somewhat clearer presentation of the beef supply is obtained by separating the milch cows from the other cattle and considering the latter alone. These figures will be found in the table which is given below:

Table showing the total number of milch cows and of other cattle and the number of each per 1,000 of population.

Years.	Milch cows. Number.	Milch cows. Per 1,000 of population.	Other cattle. Number.	Other cattle. Per 1,000 of population.	Years.	Milch cows. Number.	Milch cows. Per 1,000 of population.	Other cattle. Number.	Other cattle. Per 1,000 of population.
1850	6,385,094	275	11,393,813	491	1884	13,502,899	237	31,297,775	550
1860	8,585,735	273	17,034,284	542	1885	13,906,534	238	32,887,722	562
1870	8,935,332	232	14,885,276	386	1886	14,237,327	237	33,374,956	556
1880	12,443,120	248	24,565,333	490	1887	14,524,158	235	33,784,465	548
1881	12,538,216	242	26,013,255	502	1888	14,858,634	234	34,065,246	537
1882	12,666,031	236	28,006,734	522	1889	15,300,934	235	34,116,167	523
1883	13,127,267	237	29,650,631	536					

One of the remarkable facts brought out by this table is that since 1870 the proportion of milch cows to population has been practically constant. In 1850 there were 275 per 1,000, and in 1860, 273 per 1,000. In 1870 this number decreases to 232, or about 15 per cent., and increased in the ten years from 1870 to 1880 to 248, being at the rate of 1.6 per annum. In the seven years from 1882 to 1889 there has been a variation of only 2 per 1,000 in either direction from the number in the first named year. The reduction from 275 per 1,000 in 1850 to 235 per 1,000 in 1889, or about 15 per cent., has undoubtedly been more than counterbalanced by improvements in the quality of the stock, so that the quantity of dairy products yielded in proportion to the population is greater instead of being less than in 1850.

If we turn our attention now to the "other cattle," from which our beef supply is mostly obtained, we find, in 1850, 491 per 1,000 of population. In 1860 this number increased to 542 per 1,000, or over 10 per cent., and in consequence of the war and an incorrect estimate had dropped by 1870 to 386, a decrease in ten years of 28.7 per cent. In 1880 the number of this class of cattle per 1,000 of population had increased to 490, the proportion being almost exactly the same as in 1850. From 1880 to 1885 there was a continuous and rapid increase, which was due to the remarkable development of the range cattle industry in that period. Thus, in 1881 there were 502 per 1,000; in 1882 there were 522 per 1,000; in 1883, 536 per 1,000; in 1884, 550 per 1,000; and in 1885, 562 per 1,000. The increase in the five years from 1880 to 1885 was 72 per 1,000 of population, or about 15 per cent.

Since 1885 there has been a perceptible and continuous decrease in the proportion of cattle to population. From 1885 to 1886 this decrease was only 6 per 1,000 of population; from 1886 to 1887 it was 8 per 1,000; from 1887 to 1888 it was 11 per 1,000; and from 1888 to 1889 it was 14 per 1,000. In the four years the decrease amounted to 39 per 1,000 of population, or about 7 per cent. of the number given for 1885. The proportion of cattle to population in 1889 was almost exactly the same as in 1882.

In considering the proportion of cattle to population and in drawing conclusions as to the relative beef supply in different years, the fact should not be overlooked that there has been a great change within the last twenty years in the character of steers that have been sent to market. New and better blood has been infused into the old stock, and the result is that steers are marketed younger, weigh more, and yield a larger proportion of carcass than formerly. The beef supply obtained from a given number of cattle is for this reason considerably larger than it was a few years ago. The increased number of cattle per 1,000 of population does not, therefore, represent the whole increase in the beef supply which has taken place since 1870. There is, in addition, an increase resulting from early maturity, size, and quality which can only be estimated with great difficuly and uncertainty.

It is impossible to obtain accurate information as to the number of steers slaughtered annually in this country for beef, or to reach this number by even an approximate estimate. For this reason, the actual beef supply which yearly goes upon the market is an unknown quantity. It becomes necessary, therefore, to judge of the supply by the total stock of cattle on hand in the country. Such deductions are subject at best to grave errors which are liable to arise from a larger proportion of cattle being marketed one year than another, in order to meet temporary financial emergencies, because of lack of

feed, or because of a better price for cattle as compared with the price of corn and hay.

The demand for meat for home consumption should be tolerably constant in a series of years like those of the present decade, during which there has been no marked financial depression. There is undoubtedly, however, a considerable influence exerted upon the demand for beef by the quantity and price of pork products. In other words, when the production of pork is abundant and the price low there will be less beef consumed than when these conditions are reversed. The quantity of beef exported must also have an important influence upon the demand and upon the price.

With the facts mentioned above in mind, the following table is presented to show the relation between the relative number of cattle in the country and the mean price of steers. It is impossible to give a true average price of steers from the data on hand, but the mean price is a sufficient indication of the extent and direction of the fluctuations from year to year. The mean price of cattle and hogs given in the tables which follow are computed from quotations given in the Drovers' Journal.

Table showing the proportion of cattle to population, the value of cattle and beef products exported, and the mean price of beef steers in Chicago.

Years.	No. of cattle (excluding milch cows) per 1,000 of population.	Exports of cattle and beef products.	Mean price of steers in Chicago per 100 pounds.	Years.	No. of cattle (excluding milch cows) per 1,000 of population.	Exports of cattle and beef products.	Mean price of steers in Chicago per 100 pounds.
1878			$4.25	1884	550	$36,286,626	$6.05
1879			4.60	1885	562	32,014,002	5.15
1880	490	$31,544,360	5.75	1886	556	27,320,390	4.75
1881	502	32,801,705	5.90	1887	548	21,853,718	4.60
1882	522	22,680,272	6.77	1888	537	25,764,994	4.87
1883	536	25,004,746	5.67	1889	523	35,535,134	4.35

The above table shows that in 1880, with a steady increase in the price of steers since 1878, with 490 cattle other than milch cows to the 1,000 of population, and with an export of cattle and beef products amounting to $31,544,360, the mean price of butchers' steers in the Chicago market was $5.75 per 100 pounds. From 1880 to 1881 there was an increase in the number of cattle of 12 per 1,000 of population, the exports increased over $1,000,000, and the mean price of steers increased 15 cents per 100 pounds.

In 1882 we find a remarkable increase in the price of steers, which can not be explained by the data which has been furnished. With an increase of 20 cattle other than milch cows per 1,000 of population and a falling off in the export trade of over $10,000,000, the price of cattle not only advanced, but reached the highest point of the decade. The increase in the mean price of steers from 1881 to 1882 was 87 cents per 100 pounds.

The mean price of steers in 1883 was $1.10 per 100 pounds lower than in 1882. The exports for the year had increased $2,500,000, and the number of cattle other than milch cows per 1,000 of population was 14 greater than in the preceding year. Here again the fluctuation of price is much greater than the table would lead us to expect. In 1884, with an increase of $11,500,000 in the exports and with 14 more cattle per 1,000 of population, the price advanced 42 cents, and

reached $6.05 per 100 pounds. In 1885, with the number of cattle per 1,000 of population at the highest point and with a falling off of $4,000,000 in exports, the price dropped to $5.15 per 100 pounds. In 1886 and 1887, with a slight decrease in the relative number of cattle and with a large reduction in exports, the price of steers decreased 35 cents in 1886 and 15 cents in 1887. The export trade revived somewhat in 1888, and the number of cattle in proportion to population continued to decrease; we are not surprised to find, therefore, an advance of 27 cents per 100 pounds in the mean price of beef steers. In 1889, with an increase of nearly $10,000,000 in the exports and a decrease of 14 cattle other than milch cows per 1,000 of population, the mean price of steers declined 52 cents per 100 pounds.

Having examined the table given above somewhat critically, we are forced to the conclusion that the fluctuation in the price of steers can not be explained by the simple consideration of the number of cattle in proportion to the population or by combining this information with the statistics of the export trade. The chief disturbing condition, and one to which we have already referred, is the price of hogs. To illustrate the influence of these conditions the following table is added:

Table showing the mean price of hogs and beef steers in Chicago for the years from 1879 to 1889, inclusive.

Years.	Mean price of hogs in Chicago, per 100 pounds.	Mean price of steers in Chicago, per 100 pounds.	Years.	Mean price of hogs in Chicago, per 100 pounds.	Mean price of steers in Chicago, per 100 pounds.
1879	$3.52	$4.60	1885	$4.12	$5.15
1880	5.05	5.75	1886	4.25	4.75
1881	5.95	5.90	1887	4.88	4.60
1882	7.32	6.77	1888	5.82	4.87
1883	6.07	5.67	1889	4.38	4.35
1884	5.75	6.05			

Now, comparing the mean price of hogs and steers we find that the extraordinary advance in the price of steers in 1882 coincided with the even greater advance in the price of hogs. The largely decreased price of steers in 1883 also coincided with the equal decrease in the price of hogs. In 1884 we find a decrease of 32 cents per 100 pounds in the price of hogs and an increase of 38 cents per 100 pounds in the price of steers; this would appear to be due to the large exports of cattle and beef products in that year. In 1885 and 1886 the large number of cattle in proportion to population, the falling off in the export trade, and the low price of hogs all exerted a downward influence on the price of cattle.

The price of hogs increased considerably in 1887, but the price of steers declined still further. This was no doubt the result of the falling off in our export trade from $27,320,390 in 1886 to $21,853,718 in 1887. The slight advance in cattle prices in 1888 coincides with the much greater advance in the price of hogs, but must have been also influenced by the increased exports of cattle and beef products. In 1889 the mean price of hogs dropped $1.44 per 100 pounds, and this coincided with the decline in the mean price of steers of 52 cents per 100 pounds, a greater decline in the price of steers being evidently prevented by the large increase in the export trade. It has been evident from the receipts of cattle at the leading stock-yards of

the country that a very large number of such animals have been marketed in proportion to the stock on hand, and this has been one of the leading factors which operated to decrease the price of steers. With the decline in the prices the profits in cattle raising have been greatly reduced and in many localities this industry has been conducted at a positive loss. The inevitable tendency has therefore been to sell off the stock and reduce the business, and consequently the proportionate number of cattle marketed has been much greater than during the years from 1881 to 1884, when the industry was paying and the stock on hand was being increased. For this reason the markets of the country have not felt the influence of the reduction of the stock of cattle in proportion to the population, which the tables plainly show has occurred and which must continue at an increasing rate from year to year.

The tendency of prices with cattle will probably be to advance within the next year or two on account of the improbability of increasing the stock of cattle as rapidly as the population is augmenting, but this advance will be slow and uncertain for a number of years. It will be at least two years before the stock of cattle has been reduced to the proportion as compared to population which existed in 1878, and then the mean price of steers was but $4.25 per 100 pounds, or 10 cents less than in 1889. In other words the price of steers for several years in the future will depend more on the price of hogs, upon the value of the exports of cattle and beef products, and upon the proportion of steers marketed, than upon any changes likely to occur in the number of cattle per 1,000 of population existing in the country.

THE EXPORT TRADE IN ANIMALS AND MEAT PRODUCTS.

During the calendar year 1889 the exports of animals and meats were unusually large. The number of cattle exported reached 329,271, which is greatly in excess of those of any previous year. The largest number sent abroad in any preceding year was 190,518, in 1884. The large exports of 1889 were due to a number of conditions, primarily no doubt to the low price of cattle in the United States. The active demand in Great Britain has been an important factor, as also the freedom of nearly the whole of the United States from any dangerous contagious disease. With the rapid eradication of pleuro-pneumonia in this country and its limitation at the most to three or four counties, the confidence in American beef cattle has increased, and there is greater willingness to receive and handle them. The following tables show the exports of animals and meat products for the calendar years 1888 and 1889:

Table showing number and value of animals exported for the calendar years ending December 31, 1888 *and* 1889.

Animals.	1889.		1888.	
	Number.	Value.	Number.	Value.
Cattle	329,271	$25,673,366	154,813	$12,998,977
Hogs	87,353	741,264	19,396	159,198
Horses	4,288	689,964	2,287	417,483
Mules	3,197	376,391	2,902	362,674
Sheep	143,161	393,185	117,718	243,483

Table showing exports of meat products for the calendar years ending December 31, 1888 *and* 1889.

Meat products.	1889.		1888.	
	Pounds.	Value.	Pounds.	Value.
Beef products:				
Beef, canned	71,769,708	$6,026,970	45,298,849	$3,807,685
Beef, fresh	170,992,606	13,002,713	106,411,092	9,591,481
Beef, salted or pickled	72,915,854	3,881,077	50,377,426	2,819,047
Beef, other cured	209,968	18,658	106,255	10,665
Tallow	99,637,118	4,717,229	75,470,826	3,736,488
Hog products:				
Bacon	471,743,869	36,320,774	302,128,689	25,958,915
Hams	55,469,050	5,990,570	40,243,275	4,622,032
Pork, fresh	227,735	13,080	47,265	3,354
Pork, pickled	77,231,712	4,997,687	57,772,922	4,414,923
Lard	398,337,428	30,422,370	270,245,146	23,516,097
Mutton	350,779	30,642	205,822	16,955

The following tables, showing the exports for eleven years ending with 1889, are added for reference and comparison. It should be observed that the years referred to in these tables are fiscal years ending June 30, while in the preceding tables they are for the calendar year ending December 31.

Table showing number and value of animals exported for each year from 1879 *to* 1889, *inclusive.*

Years.	Cattle.		Hogs.		Horses.		Mules.		Sheep.	
	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.	Number.	Value.
1879	136,720	$8,379,200	75,129	$700,262	3,915	$770,742	4,153	$530,989	215,680	$1,082,938
1880	182,756	13,344,195	83,434	421,089	3,060	675,139	5,198	532,362	209,137	892,647
1881	185,707	14,304,103	77,456	572,138	2,523	390,243	3,207	353,924	179,919	762,932
1882	108,110	7,800,227	36,368	509,651	2,248	470,183	2,632	320,130	139,676	603,778
1883	104,444	8,341,431	16,129	272,516	2,800	475,806	4,237	486,560	337,251	1,154,856
1884	190,518	17,855,495	46,382	627,480	2,721	424,317	3,742	498,809	273,874	850,146
1885	135,890	12,906,690	55,025	579,183	1,947	377,692	1,028	127,580	234,509	512,568
1886	119,065	10,958,954	74,187	674,297	1,616	348,323	1,191	148,711	177,594	329,844
1887	106,459	9,172,136	75,383	564,753	1,611	351,607	1,754	214,734	121,701	254,725
1888	140,208	11,577,578	23,755	193,017	2,263	412,774	2,971	378,765	143,817	280,490
1889	205,786	16,616,917	45,128	356,764	3,748	592,469	2,980	356,333	128,852	366,181

Table showing quantity of beef products exported for each year from 1879 *to* 1889, *inclusive.*

Years.	Beef, canned.	Beef, fresh.	Beef, salted, pickled, and other cured.	Tallow.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1879		54,025,832	36,950,563	99,963,752
1880		84,717,194	45,237,472	110,767,627
1881		106,004,812	40,698,649	96,403,372
1882		69,586,466	45,899,737	50,474,210
1883		81,064,373	41,680,623	38,810,098
1884		120,784,064	43,021,074	63,091,100
1885		115,780,830	48,716,138	50,431,719
1886		99,423,362	59,728,325	40,919,951
1887	43,050,588	83,560,874	36,479,379	63,278,403
1888	40,458,375	93,498,273	49,084,420	92,483,052
1889	51,025,254	137,895,391	55,200,435	77,844,555

Table showing value of beef products exported for each year from 1879 *to* 1889, *inclusive.*

Years.	Beef, canned.	Beef, fresh.	Beef, salted or pickled.	Beef, other cured.	Tallow.
1879	$7,311,408	$4,883,080	$2,336,378	....	$6,934,940
1880	7,877,200	7,441,918	2,881,047	....	7,689,232
1881	5,971,557	9,860,284	2,665,761	....	6,800,628
1882	4,208,608	6,768,881	3,902,556	....	4,015,798
1883	4,578,902	8,342,131	3,742,282	....	3,248,749
1884	3,173,767	11,987,331	3,202,275	$67,758	4,793,375
1885	4,214,791	11,199,481	3,619,145	73,895	3,322,476
1886	3,436,453	9,291,011	3,544,379	89,593	2,144,499
1887	3,462,982	7,228,412	1,972,246	17,942	2,836,300
1888	3,339,077	8,231,281	2,608,479	9,204	4,252,653
1889	4,375,213	11,481,861	3,043,324	17,819	3,942,024

Table showing quantity and value of pork products exported for each year from 1879 *to* 1889, *inclusive.*

Years.	Bacon and hams.		Pork, fresh and pickled.		Lard.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1879	732,249,576	$51,074,413	84,401,676	$4,807,568	326,658,686	$22,856,673
1880	759,773,109	50,987,623	95,949,780	5,930,252	374,979,286	27,920,367
1881	746,944,545	61,161,205	107,928,086	8,272,285	378,142,496	35,226,575
1882	468,026,640	46,675,774	80,447,466	7,201,270	250,367,740	28,975,902
1883	340,258,670	38,155,952	62,116,302	6,192,268	224,718,474	26,618,048
1884	389,499,368	39,684,845	60,548,730	4,762,715	265,094,719	25,305,953
1885	400,127,119	37,083,948	72,073,468	5,203,943	283,216,339	22,595,219
1886	419,788,802	31,640,211	87,267,715	5,123,411	293,728,019	20,361,786
1887	419,922,955	33,314,670	85,893,297	5,641,327	321,533,746	22,703,921
1888	375,439,683	32,175,633	58,900,153	4,373,114	297,740,007	22,751,105
1889	400,224,646	34,651,847	64,133,639	4,735,077	318,242,990	27,329,173

The large export trade of the year just ended has done much to relieve the markets of this country and to maintain the price of cattle and beef. While cattle have sold somewhat lower than during 1888 the decline has been very much less than in pork, as has been shown in the preceding section of this report. The enormous corn crop of this year and the low average price of this important article of animal food has been a most important factor in depressing the price of both hogs and cattle. According to the estimates of the Statistical Division of this Department the average price of the last corn crop is but 28.3 cents per bushel, being much the lowest average of any crop raised during the last ten years.

Notwithstanding the fact that the number of cattle in this country per thousand of population has been slowly decreasing during the past four years, the large proportion of these animals that are being marketed still keeps the market overstocked and makes it extremely important that every effort should be made to maintain the export trade at least to its present extent, and, if possible, to increase it. The only danger to the trade in live cattle which has been suggested during the year is the occasional discovery of an animal which the English veterinary authorities supposed to be affected with contagious pleuro-pneumonia. It is impossible to understand how any of the beef cattle going abroad can be infected with this disease. After the most careful and extended investigations in the United States, this Bureau has been unable to discover any pleuro-pneumonia in any section from which steers are shipped. The only districts in which this disease does exist are two counties on Long Island and one county in New Jersey. The Long Island

district is isolated and no cattle from it go into the stock-yards through which the export cattle pass. The infected district in New Jersey is very nearly free from the disease, and while it is not isolated, like the Long Island district, no steers are raised for beef in this section and the stock-yards are believed to be thoroughly protected.

For the reasons given above we are led irresistibly to the conclusion that the disease found in the lungs of American steers when slaughtered on the English wharves is a sporadic inflammation which probably in most cases arises from exposure during the voyage. It is well known that generally no special characters are found by which contagious pleuro-pneumonia can be distinguished with certainty from the sporadic form of inflammation of the lungs and pleura. In making a diagnosis the veterinarian is always assisted by the history of contagion in the herds in which the disease is found, and, in the absence of such a history, if a single case of inflammation of the lungs and pleura is discovered it is difficult or impossible to make a positive diagnosis. With American steers slaughtered in England it is impossible, under existing conditions, to have any history of the animals, and as but a single steer is usually found affected in a whole cargo there is nothing to indicate that the malady discovered is of a contagious nature.

It is plain that the diagnosis of the English veterinarians in the cases of supposed pleuro-pneumonia among our steers must be more or less uncertain and open to doubt, without reflecting in the least upon the professional ability and competency of the inspectors making the examination. As this trade has grown to such an extent, and is of such great importance to the cattle industry of this country, it would seem very proper that we should take some means to determine whether the animals pronounced affected with contagious pleuro-pneumonia are really suffering from this disease. This fact could probably be determined by stationing one or more agents of the Department in England to examine the lungs of animals pronounced diseased and to determine as accurately as possible the exact conditions of their organs. The animals going abroad might also be numbered at the time of their shipment from the American ports according to some system by which any individual animal might be traced back to the herd from which it came. In this way it would be possible to determine whether such an animal had been in any way exposed to the contagion of pleuro-pneumonia. With such precautions it would seem possible to settle this long contested question as to whether the disease found by English inspectors in American steers is or is not contagious pleuro-pneumonia.

Another important consideration in connection with this trade relates to the possibility of increasing the number of animals exported. To what extent this can be accomplished it is impossible to determine. During the last six months the shipments have been about as large as possible with the present capacity of the regular lines of vessels plying between this country and Great Britain. With a continued trade of the present magnitude no doubt the carrying capacity would be soon increased, but this is one of the important factors which has prevented a still larger trade. Farmers and small shippers who have endeavored to send cattle abroad have found that the total space in the steamers had been contracted for months in advance by the large shippers. With sufficient facilities for shipment there is

no doubt that the markets of Great Britain would at present take more cattle than are being sent.

The greatest hindrance to the export trade in live cattle is the regulation of the British Government requiring that all American cattle shall be slaughtered on the docks within a period of ten days after they are landed. This prevents the owner from holding them until they can recover from the effects of the voyage and until the market is in the best condition for selling. Canadian cattle, which are allowed to enter England without any restrictions, are said to yield the shipper from $10 to $15 per head more than can be realized from steers shipped from the United States. The effect of this difference in returns is very marked, both upon our trade and upon the market value of cattle in the United States. If our shippers were able to secure $10 or$15 per head more for their animals it would of course stimulate the trade, and they would be able to pay nearly that amount more for steers purchased in this country. Such an advance in the price of export cattle would have a strong tendency to increase the price of all other kinds of stock. In this respect, then, the removal of the restrictions would be of the very greatest advantage to American cattle-raisers.

The removal of the English restrictions would also enable our shippers to send a kind of cattle which now can not be exported at all to Great Britain. There is no doubt but that our thin steers, or feeders as they are called, could be supplied to the English farmers for feeding purposes much cheaper than store cattle are now obtained from Ireland. The vast numbers of this class of steers which have been thrown upon the markets of the United States during the last three or four years have so exceeded the supply that prices have declined below the cost of production. The inevitable tendency is to force down the price of all meat-producing animals. If the foreign trade would take a considerable number of these thin steers it would be of the greatest benefit in sustaining the prices in this country. The English farmers are already agitating this question and are looking to the United States as a possible source of supply. The prices of Irish store cattle have been so high, and the danger of these animals being infected with pleuro-pneumonia is such that there is no doubt that it would be of great advantage to the feeders of both England and Scotland if they could obtain the cheap and healthy steers which are found in such numbers in all the American markets.

The number of this class of cattle which the English market could take is very uncertain. It has been suggested abroad that four or five thousand store cattle per day might be shipped from here. It does not appear probable that anything like this number could be sold to Great Britain for any considerable time. During the last five years the largest number of store cattle for feeding and breeding purposes sent from Ireland to England and Scotland in any one year is 405,540, or about 1,100 per day. This would indicate that from 100,000 to 150,000 store cattle per year would be as much as we could expect to send, if the restrictions were removed and the facilities provided for shipping that many animals in addition to the regular trade in fat cattle. Even this number would greatly relieve our markets and tend to restore prices to a point which would remunerate our farmers for the cost of production.

It has been suggested that Ireland would probably take a large number of our heifer stock for increasing their breeding herds. It is also possible that our store cattle might be sent to Ireland for fat-

tening. What the effect of this would ultimately be on our trade in fat cattle can not easily be predicted, but for a time at least it would not be great, because the store cattle shipped to Great Britain and Ireland would simply replace cattle which under other circumstances they would raise. It would, however, enable them within a few years to put more beef steers upon the home market, and in that way tend to lessen the number of fat cattle which would be taken from abroad. This need not cause any anxiety, because before such a result could be reached the over-production of cattle in this country would be a thing of the past. There can be but little doubt that within the next four or five years the population of the United States will have so increased beyond the development of the cattle industry that there will no longer be the same necessity of a large export trade.

It has been urged as an objection to exporting store cattle that it would be better for our farmers to feed them at home and ship them in a fat condition. This objection is rather theoretical than practical, and should at the present have little weight. As a matter of fact large numbers of store cattle are thrown upon our markets and depress prices, and, instead of being purchased for feeding, are killed and used for canning purposes. To send a part of these abroad would relieve the market and would not in the least lessen the number of steers that would be fed in this country. Undoubtedly it would be a better agricultural operation to feed such cattle at home and sell them fat than to sell them as store cattle, but as long as prices are so low that feeding is unprofitable they would be thrown upon the market, and it is just as well for them to go abroad as to be killed and canned in this country. The only question to be decided is, in what way would the American farmer obtain the best price for his stock. If the restrictions were removed there is no doubt that a better price could be obtained by exporting store cattle than to kill them here for canning.

The other markets of Europe are being closed against live cattle. An experimental shipment sent to Germany during the past summer realized excellent prices, and undoubtedly a large trade would have resulted were it not for the prohibitory restrictions which were at once enforced.

As has been shown above, the price of cattle in this country is greatly influenced by the price of pork. For this reason any increase of our exports in pork products would have a tendency not only to increase the price of pork in this country, but it would undoubtedly react upon the cattle trade and improve the price of beef as well. For this reason it is particularly important that efforts should be continued to secure the revocation of the prohibitory restrictions placed by various European nations upon our pork products.

There is little doubt that the markets of Europe would take all the surplus animals and meat products of the United States if these markets were not partially or entirely closed by arbitrary restrictions. Our breeding stock has now been improved until our animals compare favorably with those of any other country. They are raised under the most healthful conditions, and their price is far below that of animals of equal quality which can be obtained in any part of the world. There is, consequently, every reason why the people of Europe, where meat is so high in price as to be a luxury rather than a staple article of food with the masses, should look to this country to supply their needs.

INVESTIGATIONS OF INFECTIOUS ANIMAL DISEASES.

The account of the investigations of swine diseases which follows is interesting for several reasons. In the first place it demonstrates what, indeed, might have been expected, that both hog cholera and swine plague may exist under different forms. These differences are due to the fact that the germs which produce the outbreaks are of very different degrees of virulence. An important point is that the changes found in the internal organs on *post-mortem* examination differ materially in the same disease according to the virulence of the germ which is the exciting cause. It is therefore probable that there will be found all shades of difference in these diseases connecting the types first described in the reports of this bureau with the very distinct types described on these pages.

These extreme differences in the type of disease which may be encountered undoubtedly explain the variety of results of preventive and curative measures in the hands of different individuals. It also explains why hog cholera has shown the most actively contagious characters in some outbreaks while in others it only spreads slowly or not at all.

These researches also confirm the conclusions reached in the studies made during 1886, 1887, and 1888 as to the existence of the two distinct communicable diseases of swine which we have called hog cholera and swine plague. In some cases the germs of both diseases were found in the body of the same animal, indicating that death resulted from a complication of the two maladies. In other instances the most elaborate researches would only reveal the presence of the swine-plague germ, while at still other times only the hog cholera germ could be found. We have here further proof, therefore, that both of these germs are fatal, and that they may act each by itself in producing disease, or the two may be present at the same time and each develop its peculiar effects in the body of the same animal.

The following brief account of the investigations conducted under my direction into the nature of infectious animal diseases has been prepared by Dr. Theobald Smith, who is in charge of this branch of the work of the Bureau of Animal Industry. It will be found of great interest to all who desire a more thorough knowledge of these maladies. Only the most important results are outlined, all minor details of experiments and the autopsy notes being reserved for the report of the Bureau of Animal Industry.

ON TWO OUTBREAKS OF MODIFIED HOG CHOLERA.

I. Early in January a disease broke out in a small herd of swine near Knowles, Md., which, upon examination, proved to be a modified form of hog cholera. Considerable attention was paid to this outbreak, and the bacillus causing it was carefully studied and identified as a variety of the hog cholera bacillus as described in the reports of 1885–'88, and in the bulletin on hog cholera. The importance of thoroughly determining the various forms of swine disease, in view of prevention and extermination, and of the methods to be employed for this object, need not be insisted on at this time. The importance is a sufficient reason for these investigations, which can here be given only in abstract.

General characters of the disease.—On December 15, 1888, Mr. P. had eight fine shoats, about three months old, and on this day he

purchased a cheap lot of pigs in the Washington markets. One of these died on the way home; two others died during the two following days, and within ten days seven had died. The last one of the new lot died, greatly emaciated, January 20, after a sickness of from three to four weeks. The original lot on the farm took the disease early in January, and up to January 22 four had died. Of the remaining four, two were quite sick and two apparently well. Among the symptoms noticed by the owner was a rapid falling away in flesh, while the appetite remained fairly good up to the time of death. There was a severe cough, coupled with a nasal discharge and considerable diarrhea. In the later stages of the disease the skin of the limbs, belly, and ears became deeply reddened. The ears turned almost black, and "lopped like the ears of a dog." On the limbs and belly the skin became "scabby like a person with small-pox."

One of these pigs was examined on the farm; two others in which disease was manifest were taken to the experiment station of the Bureau, there placed in clean, disinfected pens with board floors, and fresh pigs put with them to determine whether the disease was communicable or not. The following table shows that the disease could be communicated from one animal to another without the intervention of the soil. It also gives the time elapsing between the exposure and the death of the animal exposed:

No.	Age, etc.	Placed in pen.	Death.
1	Examined on farm	....	Jan. 21
2	Brought to station	Jan. 21	Jan. 22
3	......do	...do ..	Jan. 30
121	Three and one-half months old	Jan. 22	Feb. 17
126	Four months old	Feb. 12	Mar. 6
128	......do	...do ..	Mar. 5
116	Five months old	Mar. 5	Mar. 29

A few pigs placed in the pen with these did not take the disease; a few died rather prematurely on account of injuries received by fighting with one another. The four cases recorded in the table (Nos. 121, 126, 128, 116) are sufficient to establish the fact that a period of from three to four weeks is sufficient from the first day of exposure to destroy the animal. It should be borne in mind that this period holds only for pigs constantly exposed to virus in a small pen.

Lesions produced by the disease.—Unfortunately this outbreak, like so many studied since 1886, was a mixture of two diseases. We may now, after the investigations of the past few years, lay down the general statement that almost all extensive lung disease is caused by the swine plague germ. At the same time it is difficult to determine with any degree of certainty, when the outbreak is of a mixed character, the exact role which each germ plays in causing disease of the stomach and intestines. The hog cholera germ may cause certain injuries to the mucous membrane, and the swine plague germ coughed up from the air-tubes and swallowed may cause additional injury to the whole digestive tract. It is also impossible to determine definitely which germ enters the body of the pig first. Either may prepare the way for the other. As there is much variation in the activity or virulence of either germ, it is very probable that the most virulent makes the first attack and thereby paves the way for the other. We may likewise assume that the germs are transmitted together from one herd or pig to another.

In the pigs obtained from the farm (Nos. 1, 2, 3) as well as some of the exposed, the lungs, stomach, and large intestines were diseased. The lung disease was a more or less extensive broncho-pneumonia or catarrhal pneumonia, involving also the larger air tubes. The solidified lung tissue was nodular to the touch, the nodules being caseous masses in the ultimate bronchioles and air-cells. The filling up of these spaces with cellular elements had gone on to such a degree that there was distinct saccular dilatation of the small air-tubes (bronchiectasis). With this lung disease the swine-plague germ was always associated.

The stomach was either deeply reddened, hyperæmic in the fundus, or else there was (outside of the fundus) a peculiar diphtheritic inflammation, accompanied by cellular exudation, necrosis of the mucous membrane, and subsequent ulceration. This lesion had not previously been observed in swine disease, excepting in a few pigs which had been fed with cultures of hog cholera bacilli. The hyperæmia of fundus and diphtheritic condition of the remainder of the mucosa were in a few cases found associated together.

The lesions of the large intestine were quite varied in character. In several cases they consisted of large neoplastic projections from the mucous membrane, often one-half inch high and one inch wide. The neoplasms were very firm, yellowish white, capped by a thin black slough and extended into the muscular coat, or even to the serosa. Some had the concentric markings quite common in hog cholera, while others were irregular in outline. The more common appearance presented in this outbreak by the large intestine was a complete necrosis of the mucosa over large areas. The mucosa itself was converted into a rather firm, yellowish-white, homogeneous layer, the surface of which was made irregular by small lumps of caseous matter reminding one of rough cork-lining. In some cases the sheet necrosis was more smooth. In a few instances the upper large intestine was beset with numerous small ulcers which seemed to have their origin in the solitary follicles and mucous glands.

How far the swine plague germ contributed to the disease in the digestive tract it is of course impossible to say. Its presence was detected several times by inoculating rabbits from the mucous membrane. The investigation as a whole seems to indicate that its action was a subordinate one.

Characters of the hog cholera bacillus causing this disease.—The methods employed in isolating the pathogenic organisms were in general the same as those hitherto employed. They consisted in tube cultures usually agar and bouillon from the spleen, in plate and roll cultures (agar and gelatine), from the diseased lungs and pleura, and from the recently diseased mucosa in the stomach and large intestine. The cultures were re-enforced by the use of inoculations into rabbits from the same organs, as well as from cultures made directly from the pigs to test the disease-producing character of the bacteria thus obtained. The results from these different lines of work usually confirmed one another and may be briefly summarized. The hog cholera bacilli were found in the spleen in the majority of the cases examined. In several cases plate cultures from the deeper layers of diphteritic deposits and ulcers contained a large number of colonies of the same bacilli. The swine plague bacteria were present in the diseased lungs and occasionally found in the digestive tract. The hog cholera bacillus of this outbreak differed in a number of characters from the one found in outbreaks since 1885,

It grows more actively in bouillon-peptone, causing a considerable turbidity of the liquid. Its colonies in gelatine are larger, the surface colonies more especially so. These spread out in the form of fleshy, perfectly round, flat discs on the gelatine layer. The bacilli themselves are perhaps slightly larger than the true hog-cholera bacilli. In other respects they are the same.

When we come to the pathogenic effect a decided difference is observed between the two forms. Calling, for the sake of convenience, the first described bacillus *a* and the one now under consideration *b*, the latter is much less virulent. This has been observed both on pigs and on smaller animals, such as rabbits and mice. Pigs, when fed with bouillon cultures, became very sick for a few days and had more or less diarrhea. Recovery usually took place in a week. One pig was fed after a fast of a day with some carbonate of soda solution before receiving as a drench somewhat less than a pint (400 cubic centimeters) of a bouillon culture of this bacillus. It died in four days, and at the autopsy considerable inflammation of the stomach and intestines was observed. The germs were not found in the spleen, but from the mesenteric glands they were obtained in roll cultures, no other bacteria being present. These experiments are sufficient to demonstrate the pathogenic power of this bacillus on pigs. They also show that this power is decidedly inferior to that of bacillus *a*.

The effect on rabbits deserves a moment's consideration, owing to the importance of rabbit inoculation in the study of the hog cholera bacilli. The bacillus *a* may be considered quite invariably fatal to rabbits, even in very minute doses. This is not true of bacillus *b*, however. When a moderate quantity of a bouillon culture (one-quarter of a cubic centimeter) is injected beneath the skin, the rabbit may die in from ten to twenty days. The lesions observable are a rather extensive subcutaneous purulent infiltration, often developing into an abscess which may rupture. The spleen is small, the liver without necrotic foci. The Peyer's patches of the small and large intestine and the follicles in the contracted terminal portion of the cæcum are swollen and appear as whitish points or nodules, varying in size. These may break on the surface of the mucosa and become converted into ulcers with adherent sloughs. Not infrequently the transverse folds in the cæcum and the mucosa in the upper portion of the colon may be studded with typical "hog cholera" necroses or ulcers. Here we have the lesions of hog cholera in pigs reproduced with a remarkable clearness in rabbits by subcutaneous inoculation. While subcutaneous inoculation is not generally fatal to rabbits, intravenous injection of very small doses of bouillon cultures (one-twentieth to one-fifth of a cubic centimeter) is more certain in its effects, and the same intestinal lesions are produced which have been described as the result of subcutaneous inoculation.

These rather remarkable lesions at first sight might induce us to differentiate widely this organism from the true hog cholera bacillus *a*. Their essential identity is demonstrated by the very instructive results obtained by inoculating attenuated cultures of the bacillus *a*. We then are able to produce the same peculiar follicular swelling and ulceration in the intestines, while the spleen remains small and the liver free from necrosis.

Another proof of the essential identity of these two bacilli, *a* and *b*, was furnished by rabbit vaccination. A number of rabbits were inoculated twice with the bacillus *b* in quantity sufficient to produce a rise of 3° or 4° F. in the temperature of the animals for a week or

longer, but not sufficient to prove fatal. Subsequent inoculation with the virulent bacillus *a* failed to kill these animals, although their temperature rose 4° or 5° F., and the control animals all succumbed. In other words the bacillus *b* proved to be a vaccine for the bacillus *a*.

The investigations with reference to this bacillus have elicited the following facts: (1) It is essentially identical with the true hog cholera bacillus as shown by rabbit experiments; (2) it is much less pathogenic than the latter.

II. During September Dr. Kilborne visited Clarke County, Va., where more or less swine disease was prevalent. The disease seems to have been lingering along the river below Berryville since last winter, and became especially virulent during August. It was estimated that about 75 per cent. of the swine in the vicinity of Berryville succumbed to the disease. At the time of the inspector's arrival there were very few sick, many having died during the two or three weeks preceding. The symptoms observed by the owners of herds were frequent coughing, diarrhea, and occasional vomiting. The affected animals lost flesh and strength very rapidly. There were also general reports of skin disease accompanying these symptoms. Pieces of skin were said to drop off, leaving raw, deep sores. The skin of the ears and belly became purplish and was covered with sores.

Owing to the meager material on hand, the notes are given somewhat more in detail:

Two sick pigs were brought to the Experimental Station of the Bureau and there confined in an isolated disinfected pen. At the same time a healthy pig, whose history was well known, was penned with them. Both pigs arrived at the Station September 4. One (No. 3) died September 11, the other (No. 4) September 23. The former had ulcers on gums and tongue, inflammation of the mucous membrane of the stomach and small intestines, and ulcers in cæcum and colon; parenchymatous inflammation of kidneys. The anterior half of lungs hepatized; bronchitis. The lymphatics throughout the body considerably enlarged, reddened, and mottled with paler spots and occasional petechiæ. The mesenteric glands differed, however, in presenting a peculiar yellowish-green color, due to caseation, which was distributed in small masses throughout the gland substance. Cultures on plates of gelatine and agar, in tubes of bouillon, agar, etc., from blood, spleen, liver, lungs, mesenteric and inguinal glands were unsatisfactory, owing to the fact that every organ examined contained several varieties of organisms. The swine plague germ was found in four organs; besides this were streptococci and various non-motile organisms. From Esmarch rolls a germ closely resembling the modified hog cholera bacillus was obtained, but its effect on one rabbit was negative. The second case was more satisfactory in this respect. This lived to September 23, as stated above. The lesions found at the autopsy were the same as in the preceding case, so far as the lungs, mesenteric glands, kidneys, and stomach are concerned. In addition to these there were small infarcts in the spleen. The lesions in the intestines differed quite materially. The mucosa of ileum was covered by a diphtheritic exudate and its wall very much thickened. The mucous membrane of the cæcum and colon was likewise diphtheritic; only one ulcer penetrating the mucosa was found. From the spleen and liver numerous

hog cholera bacilli were obtained, and their effect on rabbits was the same as that of the modified bacillus already described. From the diseased lungs swine plague germs were obtained.

The healthy pig penned with them September 18 was killed December 9. The skin of the major portion of the body was covered by firmly adherent, thick, dry crusts or scabs, and in general the condition of the pig was unthrifty and poor. The internal organs were normal, however. In the cæcum and upper colon there were a few cicatrices indicative of former ulceration.

The discovery of this modified hog cholera raises several important questions. May there not exist in different parts of our country other varieties of the hog cholera bacillus perhaps still less virulent than the one described? If so, it necessarily follows that there must be considerable differences in the general character of the disease and in its infectious and contagious qualities. Bacteria which possess pathogenic activities in a high degree will generally make the resulting disease contagious. The germs carried out of one animal will, sooner or later, produce disease in another animal coming in contact with them. This direct transmission of bacteria from one animal to another, and the consequent outbreak of disease in the second animal, makes the disease *contagious,* whether the bacteria be carried in the dust of the air or transferred to the soil in the discharges and the urine to infect the food of another animal. The transmission of bacteria, in whatever manner, from one animal to another, provided the bacteria do not undergo any necessary changes during the passage, constitutes contagion. This is the character of the virulent hog cholera. Animals placed in contact with such disease in pens where there is no "soil" whatever will take the disease and die.

When we come to the weaker varieties of this germ the case is different. Large quantities of virus do not prove fatal, though they may cause severe disease, and in order that the bacteria may manifest their highest potency the animal must have been debilitated by some other cause. This was illustrated in the feeding experiment cited above by the use of the carbonate of soda. This made the stomach alkaline and allowed the bacteria to pass into the intestine. Any derangement of the stomach by which its activity is reduced may act in the same way. Overfeeding or sudden change of feed, disease of the liver, ascarides plugging the bile-duct, disease of the lungs, all these tend to impair digestion directly or indirectly and prepare the way for the introduction and unchecked multiplication of the specific bacteria. It is also evident that in such outbreaks all animals will not be attacked unless all have been subjected to the same or similar debilitating influences. In other words, the disease is communicable, but only under special conditions. Unfortunately these debilitating influences usually do come upon all animals in a herd alike, whether they pertain to the food, to exposure, or to animal parasites.

It is evident that many erroneous impressions will be gained by insufficient knowledge concerning such modifications of the disease, especially in regard to treatment and prevention. An inoculation may appear to protect animals from a mild type of the disease when it would be unable to do so from a virulent one. Again, the inoculated animals may have been placed in such conditions that their system would have resisted the disease even without inoculation. The same is true with regard to so-called remedies and preventives.

These may prove efficacious in one type of disease, but when applied to others the remedy may utterly fail. As a general rule only those remedies or preventives are worthy of the name which prove efficacious in the genuine virulent hog cholera. This, according to our experiments, has proved transmissible from animal to animal under any circumstances.

The existence of such modifications still more complicates the study of swine diseases already made difficult by the frequent admixture of two diseases, hog cholera and swine plague, in the same herd. The additional difficulty arises from the fact that the less virulent germs often fail to penetrate into the internal organs, such as the spleen and liver, where they are easily detected, and remain limited to the intestines or the lungs wherever the disease process is actually going on. Under certain conditions the detection of bacteria in the affected lungs is a very simple matter, but it is always a difficult and frequently an insoluble problem when the investigations must be limited to the miscellaneous, ever-changing contents of the digestive canal. The importance of exercising the greatest care in investigations and the greatest caution in coming to conclusions must be impressed upon all those who are investigating what seems to be exactly the same disease in different parts of our country.

These investigations also suggest the possibility that there may be still other diseases falsely called hog cholera, which are of a purely temporary character, and which are called forth by various unsanitary conditions. Such diseases, if they should be proved to appear now and then, would not be communicable, but would be self-limited and disappear when the exciting cause is removed. Such localized diseases have been reported as occurring now and then among the human family after eating spoilt or diseased meat. Only lately has attention been directed to the bacteriological side of these occasional diseases. A very good illustration is reported by Professor Gärtner,* in Jena.

A cow affected with diarrhea, accompanied by discharge of mucus from the bowels, was slaughtered and the meat used for food, because the inspector, after a careful examination, pronounced it normal. Of about ninety persons who ate of this meat, either raw or boiled, fifty-seven became ill from two hours to several days thereafter. The severity of the disease varied with the quantity of raw meat consumed. One person who consumed 1½ pounds died in thirty-five hours. From the meat of the slaughtered cow, as well as from the organs of the deceased person, a bacillus was obtained which had not been before recognized, and which was denominated *bacillus enteriditis*. It proved to be pathogenic on the smaller experimental animals such as mice, guinea-pigs, and rabbits. It destroyed them when inoculated or fed in sufficient doses, and usually produced inflammation of the intestines. There could be no reasonable doubt, in view of the investigations, that this bacillus was the cause of the epidemic. At the same time it is not known to be the cause of any recognized infectious disease in man. According to investigations made subsequently in the province of Herzegovina, by Karlinski,† this *bacillus enteriditis* is not an uncommon inhabitant of the dried meat of that country, and he traced a case of acute poisoning to such meat. He also claims to have found the same germ in the intestines of healthy animals and of man.

* Corresp. d. allg. ärztl. Vereins Thüringen, 1888.
† Centralbl. f. Bakteriologie (1889), VI, 289.

The manner in which swine are fed in some parts of our country does not preclude the occurrence of disease very similar to that just described. At the same time it would by no means deserve the name of hog cholera. It might attack all the animals of a herd at the same time, stop when these had recovered or died, and thus give the impression that certain preventives or cures had brought about the recovery when perhaps a change of feed would have resulted equally well. The dangers to which domesticated animals, and especially those of the omnivorous type, are exposed by the miscellaneous food which they receive, contaminated by germs of every kind, are very great, and it would seem, when we take into consideration the progress of investigations in the field of preventible disease, that the methods of rearing swine must be radically changed and adapted more to sanitary laws if disease is to be kept in check. The hypothesis of the occurrence of disease not to be classed under swine plague or hog cholera receives some support from the fact that we occasionally meet with disease in swine involving the lungs or the intestines, or both organs together, from which no positive bacteriological results are obtainable. Sometimes unusual forms of bacteria will predominate, at others such ubiquitous germs as streptococci are the only ones to be detected. These facts indicate either the insufficiency of bacteriological methods or else the production of disease, under aggravated conditions, by germs which, under ordinary circumstances, must be regarded as harmless.

SWINE PLAGUE.

It has already been stated that lung disease associated with the swine plague germ was present in the outbreaks of modified hog cholera described briefly in the preceding pages. It has been one of the chief difficulties in the study of this disease to obtain it free from complication with hog cholera. These mixed outbreaks, as they might be denominated, have been encountered with rare exceptions ever since 1886. They have led to various attacks on the work of the Bureau, attacks as unfounded as they seem to be inspired with personal malice. It was maintained that swine plague was merely grafted on hog cholera or secondary to it. A careful survey of facts would lead one to adopt the conclusion that in a fraction of the outbreaks just the reverse is true, and that hog cholera attacks the herd after it has been invaded by the infectious lung disease.

I. During the fall of 1889 several epizootics of swine disease were again carefully studied in order to elucidate as far as possible the relation between the two diseases of swine plague and hog cholera. The first epizootic appeared among swine fed at a slaughter-house near the Station. Late in September the owner had purchased in the Washington markets thirty-five animals in two lots, possibly in three. They began to die about one week thereafter, and within little more than one month they were all dead. A small number had already succumbed before the outbreak came to our notice.*

Thirteen animals were examined. They were small, weighing from 25 to 35 pounds each. It is impossible, in a small space, to give an adequate idea of the lesions manifested in these thirteen cases. In all, the lungs and the large intestine were diseased, but the extent of the disease varied considerably. Of the lung tissue from one-half to

*A small number of older animals on the place and freely mingling with these did not take the disease.

three-fourths was hepatized. The bronchi contained a muco-purulent secretion. The hepatization was of a bright red color, mottled in many cases with greenish-yellow, necrotic areas; in others the necrosis was absent. The pneumonia was accompanied in most cases by more or less extensive exudative pleuritis, limited, at least in its severer form, to the covering of the solidified lung tissue. The pericardium, and more rarely the epicardium, was covered by the same exudate. As a rule the lobes of the lungs were glued to each other, to the chest wall, and to the diaphragm. The lesions of the digestive tract involved the stomach and the large intestine. The former was usually hyperæmic, bordering on hemorrhage, occasionally with localized sloughs or ulcers. The large intestines were as a rule ulcerated, but the ulceration varied very much. In some animals it was limited to the follicles, in others the necrosis of the mucous membrane was very extensive. Pigmentation and hyperæmia were not uncommon.

The bacteriological examination comprised cultures on gelatine, agar, and in bouillon, from the spleen, liver, and pleural exudate; gelatine and agar roll and plate cultures from different regions of the diseased lung tissue, and the inoculation of rabbits with bits of the same tissue. The results of this laborious examination are somewhat different from those obtained from former outbreaks, and they indicate how important it becomes in these inquiries to know something of the previous history of the infected herd.

No.	Nature of the germs obtained.	Remarks.
1	Swine plague germs	Ulceration of large intestine slight; lung disease severe.
2	......do	Do.
3	Hog cholera germs; swine plague germs only in lungs.	Ulceration very extensive; lung disease moderate.
4	Hog cholera germs	Do.
5	Swine plague germs	Ulceration moderate; lung disease moderate.
6	Hog cholera germs	Do.
7	Swine plague germs	Do.
8	Swine plague	Ulceration slight; lung disease severe.
9	Swine plague and hog cholera germs.	Ulceration extensive; lung disease severe.
10	......do	Do.
11	......do	Ulceration moderate; lung disease moderat
12	Swine plague germs	Ulceration moderate; lung disease severe.
13	Hog cholera germs	Ulceration slight; lung disease moderate.

An examination of the table shows that in spite of the careful search no hog cholera bacilli could be found in Nos. 1, 2, 5, 7, 8, and 12, while on the other hand no swine plague bacteria could be found in Nos. 4, 6, and 13. The rest—Nos. 3, 9, 10, and 11—contained both hog cholera and swine plague bacteria. In general, the lesions corresponded with the bacteriological facts. This was particularly so with the four first cases examined. In Nos. 1 and 2 the ulceration of the large intestine was slight, apparently follicular, while the lung disease was very severe. In Nos. 3 and 4 the reverse was true; the intestinal ulcers were very large and numerous, the lung disease moderate and without pleuritis. In Nos. 1 and 2 no hog cholera bacilli could be found, although special attention was paid to this point. In No. 4 no swine plague germs could be found; in No. 3 they were only detected by rabbit inoculation with bits of lung tissue. In cultures from the other organs hog cholera germs were present exclusively. In the other cases a similar parallelism between the lesions and the germs found was present, but not so well marked as

in the first four cases. If we had limited our investigations to Nos. 1 and 2 we should have no doubt considered the outbreak as swine plague. If we had only examined No. 4 we should have pronounced the disease hog cholera, whereas, in fact, the herd was affected with both diseases.

If we should attempt an explanation, by using statements which can not be clearly demonstrated as facts, we might come to the following conclusions: The pigs, which came from two or three different sources, came infected with two different diseases. This view will be borne out by the earliest four cases actually examined. Unfortunately six or seven of the herd were dead before we had any knowledge of the outbreak. These might have helped us still more in coming to some conclusion. When the animals were thrown together secondary infection took place, those having swine plague becoming infected with hog cholera, and those having hog cholera with swine plague (see Nos. 9, 10, 11). As regards the intestinal lesions in those animals in which, after very diligent search, no hog cholera bacilli could be found, we do not venture an opinion, because the hog cholera bacilli may have been limited in their distribution to the digestive tract, which was not examined directly. What may be maintained, however, is that in these cases the internal organs were flooded with swine plague germs; the diseased lungs, also flooded with swine plague germs, after very careful examination proved to be free from hog cholera germs. When we take into consideration the fact that when hog cholera germs are at all present in the diseased animal they generally appear in all organs, and that they are far more easily detected than are the swine plague germs—the latter generally failing to grow on gelatine—we may safely assume that in those cases in which hog cholera germs were not detected they were either wholly absent, or, when present, exercised a very minor influence on the course of the disease, and that the swine plague or infectious pneumonia was the primary disease and the cause of death.

In view of the skepticism which prevails to some extent as to the existence of a disease independent of hog cholera, the following inoculations, which clearly demonstrate the pathogenic effect of the swine plague germ, are briefly reported:

Four pigs were inoculated with a turbid suspension of swine plague germs, grown on *agar*.

No. 272 received 2 cubic centimeters subcutaneously; killed after three weeks. No effect.

No. 273 received one-half cubic centimeter through the right chest-wall into the lungs. Sick for a week, breathing with difficulty. Seems to have recovered after two weeks, when it was killed. Diaphragm pressed downward. Both pleural sacs converted into large abscess cavities, surrounded by thick pyogenic membranes, and distended with a thin, milky fluid. Both lungs compressed into a very small space. Pericardium and epicardium covered with purulent exudate.

No. 274 received 1 cubic centimeter of the suspension into the abdominal cavity. Dead in twelve hours. Exudative peritonitis, pleuritis, and pericarditis.

No. 275 received into the right lung 1½ cubic centimeters of the suspension. Dead in sixty hours. Double exudative pleuritis and pericarditis. Right lung almost entirely necrosed; the left has a typical pneumonia in principal lobe. Intense catarrhal inflammation of the stomach.

II. Another outbreak of swine disease among penned pigs not far from the Station, during November, 1888, deserves a brief description here, because of the very curious and instructive fact that swine plague occurred in one pen and hog cholera in another; nor was it possible to find hog cholera germs in the swine plague pigs, or swine plague germs in the hog cholera pigs. The details as regards the characters of the surroundings, the pens, etc., must be reserved for future publication. A sow in one of the pens became sick November 8, and died suddenly next day. It had seven pigs seven weeks old, small for their age. All of these died in the space of four days, from November 9 to November 12, inclusive, and all but two were examined. The disease in these five cases was very much alike. The lungs were hepatized, the hepatization involving from one-half to two-thirds of the entire lung tissue, and invariably the dependent portion. The hepatization was quite firm, varying from a granular, grayish-red, mottled appearance to an occasional hemorrhagic infiltration.

Exudative pleuritis extending to the pericardium was present in every case. The stomach was usually contracted, empty, containing a bilious, catarrhal coating. The liver was unusually firm to the touch. The large intestine more or less hyperæmic or pigmented, with slight roughening (necrosis?) of the surface in one case. There was not a sign of ulceration in any of these five cases. Mingled with the feces in several instances were masses of a soft, pale, yellowish color, which were probably exudates from the congested membrane. Careful bacteriological examination of the spleen, liver, lungs, and pleura resulted in finding swine plague germs in every case. The hog cholera germ was conspicuous for its absence. It is difficult to see how the disease in these cases can be credited to anything but the swine plague germ. The hyperæmia of the large intestine, which might have resulted in croupous or diphtheritic inflammation later on, may be explained by the swallowing of the virus either as it came from the bronchial tubes or as it was mixed with the food by the nasal discharges and feces of the diseased animals.

In another pen, but not in communication with the last, were five pigs recently purchased (in October). Three died, of which one was examined. The two remaining sick ones were taken to the Station, and they, together with the viscera of the one examined, were made the starting point of a typical hog cholera outbreak. The one examined was affected with *extensive necrosis and ulceration of the cæcum and colon, hemorrhagic lymphatics scattering foci of hepatization in the lungs without pleuritis.* In the various organs, including the lungs, hog cholera bacilli were present in large numbers. No swine plague germs detected.

In a contiguous pen one pig died. This proved to be a case of hemorrhagic hog cholera without lung disease. Beginning necrosis, with hyperæmia in the intestine, hemorrhagic kidneys and lymphatics, and hemorrhages in different parts of the body. In this case only hog-cholera bacilli were found. The other pens on the farm remained free from disease.

If we sum up the result of the investigations we have five animals in one pen affected with extensive lung tissue, which is associated with swine plague germs only. We have two other pens, not in communication with this one, affected with hog cholera only. These facts demonstrate as clearly as any which we have thus far been able

to obtain that swine plague or infectious pneumonia may appear as an independent disease, fraught with a high mortality.

In connection with these investigations a few facts which may be of interest to those who may engage in this work in different parts of our country are briefly given. The swine plague germs found in these two outbreaks differed considerably in their pathogenic power. In fact they must be regarded as distinct varieties in this respect. The germ obtained from the mixed outbreak first described was sufficiently virulent to kill rabbits in from sixteen to twenty hours, even after the slightest prick of the lancet upon which a minute speck of the germ growth had been deposited. In all the organs of the dead animal the germs were present in large numbers. The germ obtained from the outbreak just described differed in causing death in from three to seven days. Instead of the septicæmia and the presence of germs in the blood of all organs they were restricted more or less to the peritoneal or pleural cavities, or to both, where they produced exudative inflammation.

In swine in the earliest acute cases of swine plague the lungs are practically a pure culture of the swine plague germs, and from the pleuritic exudate pure cultures can always be obtained without resorting to plate cultures. Animals which succumb later on are less and less suitable for examination. The swine plague germs are being destroyed in the lung tissue by the secondary processes of degeneration going on, and their place is taken by various bacteria from the air passages, which have no causal relation to the disease. The pleural cavities are lastly invaded by forms from the dead lung tissue, and this invasion may even extend to the spleen and other organs. The lesson to be drawn from these facts is obvious. In any outbreak all the animals should be examined and the investigation should never be limited to a few cases from a miscellaneous variety of epizootics. The chances of being misled are particularly great in the study of swine plague, unless we trace the disease from the earliest to the last cases, which is equivalent to saying from the most acute to the most chronic. Unfortunately for the investigator the existence of disease is rarely reported until a number of animals are dead, and these among the best cases for study which the whole epizootic has to offer. Another fact to be borne in mind by the investigator is the comparative uselessness of gelatine for cultivations. Neither of the two varieties of swine plague germs described could be made to grow upon this medium with any degree of certainty.

Lung worms associated with these outbreaks of swine plague.—The autumn of 1889 seems to have been very favorable to the lung worms (*strongylus paradoxus*), for most of the pigs of the swine plague outbreaks were infested with them. They were, as a rule, limited to the air tubes of the large principal lobe of both lungs. They were frequently so numerous as to completely occlude the principal bronchus and collateral branches. The resulting pneumonia was limited to the posterior (caudal) extremity of the lobe and to scattered regions through which the plugged branches passed. In fact, in a few cases examined from another outbreak, they were so numerous as to become a sufficient cause for all the lung disease observed. It is of considerable importance to determine how far the lung worms in their migrations may be held responsible for carrying disease germs into the lungs. In the epizootics of swine plague the pneumonia caused by the worms was limited to the caudal tip of the principal lobe, while the infectious pneumonia invades the small an-

terior lobes first, then the principal lobe. If, therefore, there exists any relation between the lung worms and the swine plague at all, it must be regarded as indirect. The life history of these parasites, by reason of their wide-spread destructive presence in certain seasons of the year, demands careful investigation. Experience at the Bureau Station seems to show that swine kept off the ground in pens do not become infested with these parasites, and this experience is worthy of more careful observation.

Experiments on preventive inoculation in hog cholera.—Experiments of this kind have been conducted ever since the discovery of the hog cholera bacillus in 1885. They have been hampered and interrupted by a variety of causes. Among these may be mentioned the season of the year, the difficulty in obtaining pigs above suspicion as regards previous exposure, as well as in subjecting them properly to infection after they have been inoculated. The latter is by no means of small importance when we consider that swine diseases are apt to appear in certain seasons of the year, and that it is difficult to get material from natural outbreaks of a sufficiently virulent character except at these seasons. We must also guard against exposing them to mixed outbreaks of swine plague and hog cholera. These causes individually and combined have greatly retarded this work.

There are other difficulties to be encountered even after the protective inoculation shall have proved a success. These difficulties arise from the existence of two diseases often appearing together in the same herd, often independent of each other. The vaccine of one disease will not protect the animal from an attack of the other; at least there is nothing to warrant the assumption that it will in the results thus far obtained from experimental inquiry. The question concerning the distribution of these diseases is one which can not be solved by the Bureau alone, owing to the enormous amount of work which it involves, and which properly belongs to the Agricultural Stations of the different States. This question of distribution should be solved, at least in a partial manner, before any vaccine of living germs is indiscriminately distributed over the country.

In carrying on experiments of preventive inoculation this year, it was thought best to continue the investigations on the attenuation of virus, and to carry this attenuation to such a degree that the bacteria would not be likely to cause an epizootic of the disease even if, by accident, they should become scattered about. The details of the method employed will be published in the report of the Bureau. The bacteria were attenuated by heat and to such an extent that rabbits were not killed by a dose at least fifty times that required to kill them when the virus was not attenuated. It was also shown that when rabbits have been inoculated with this attenuated virus, and subsequently with virus somewhat stronger, they do not die when inoculated with the original virus. It was thus demonstrated, upon rabbits, that the inoculation with attenuated virus makes the animal insusceptible to the strong virus.

In making this test upon pigs the conditions are somewhat different. Pigs take the virus into the intestines with their food; in the rabbits, it was put under the skin. The important question arises: Will subcutaneous inoculation protect the animal from intestinal necrosis and ulceration? In endeavoring to solve this problem the experiments of the Bureau are keeping in view the following important conditions: (1) The animals must be young, unexposed hitherto

even to the suspicion of disease. (2) There must be a large number of control or check animals of the same age and breed, which are to be subsequently exposed to the disease under precisely the same conditions as the vaccinated animals. (3) The disease to which they are exposed must be carefully studied, the presence or absence of swine plague determined, and the virulence of the hog cholera germs tested on rabbits. It must be virulent enough to prove fatal to the control animals. This last condition is of very great importance. We have seen from what has been said that not only do hog cholera bacteria vary very much in virulence in different outbreaks, but we have encountered swine disease occasionally in which neither hog cholera nor swine-plague germs could be found. The conclusions drawn from inoculation experiments which are tested by exposure to a mild form of the disease, or to a disease which is not hog cholera at all, might be, to say the least, misleading. Thus, in the inoculation experiments of the Bureau made in 1886, it was clearly demonstrated that small doses of unattenuated cultures injected beneath the skin do not protect from the virulent hemorrhagic form of hog cholera when the animals are placed in infected pens where there are always plenty of sick ones. Whether the animals would have died if allowed to range over a farm where the virus is scattered over a large area and thus diluted, and where each one would have received less, is a question to be tested by itself, although it by no means promises well in view of the results obtained in pens.

At present a herd of about fifty pigs is being exposed to the disease at the station. One-third are control animals of the same breed as the vaccinated ones. These received varying quantities of culture liquid in which attenuated bacteria had multiplied. The exposure consisted in placing in the pens about eight pigs infected with hog cholera. As the exposure has been just begun, the results of the experiment can not be given in this report.

INVESTIGATIONS OF TEXAS FEVER.

Since the introduction and development of better methods in the study of micro-organisms, it seemed desirable to make more careful and elaborate investigations of this disease in order to determine if possible its nature and cause, and to derive therefrom rational means of prevention in addition to those already well known and applied. The difficulties in the way of such investigations are insurmountable, unless cases of the disease can be obtained which are within reach of a well equipped laboratory where the more delicate methods of research may be applied. The material at the disposal of the laboratory has therefore been very meager, in spite of continual efforts to obtain it during the season when it is most apt to appear north of the permanently infected area.

During the summer of 1888 about five cases were examined. The disease had broken out in Maryland, about 60 miles from the laboratory, and in spite of the care exercised in hunting it up only five cases fell into the hands of the inspector in a condition fit for examination. The various organs were brought in specially devised refrigerator cans to the laboratory, where they were subjected to a careful microscopical and bacteriological examination. The result of this work was in general negative. The internal organs were free from bacteria so far as the microscope and cultivation were able to go. At the same time investigations conducted in this manner were open

to many objections, and during the summer of 1889 it was decided to produce the disease at the Experiment Station of the Bureau and thus have cases under observation from the beginning of the infection. Cattle from North Carolina, brought to the station during the last week in June, infected the pasture there so that the first native animal died late in August. Another importation of North Carolina cattle, late in September, was equally successful in giving rise to a second outbreak of the disease.

During the entire season eleven head of exposed native cattle died. Besides these fatal cases a number of cases which terminated in recovery came under observation. The symptoms and lesions may be very briefly summarized.

The first indication that the disease had entered the system and was there unfolding its destructive activity was a continuous high temperature, fluctuating very slightly and subsiding only when death or recovery ensued. The temperature rose from 101°–102° Fahrenheit to 106°–107° Fahrenheit, and in the fatal cases remained high from four to fifteen days. After a variable number of days the high temperature was accompanied by general weakness lasting but a few days, when death ensued. A few days before death the urine became more or less deeply colored with hæmoglobin, and in nine out of eleven cases the bladder after death contained deeply tinged urine. In the tenth case hæmoglobinuria was present three days before death. The destruction of red globules causing this condition could be easily demonstrated by examining blood taken from an incision through the skin. In severe cases, on the day before death, the number of red globules had fallen to about one million in a cubic milimeter of blood, the normal being about five and a half million. In one case, now recovered, the corpuscles were reduced in number nearly one-half several days before the temperature fell to normal, and a week later the number had not yet risen to three million. This enormous loss of red globules gave the blood an exceedingly thin, watery appearance. At the autopsy, besides the condition of the blood as noted, it was found to coagulate rapidly and form clots of unusual firmness.

The following description of the most obvious lesions will apply with more or less emphasis to all ten cases. The spleen is enlarged to several times its natural size. When incised, the tense capsule retracts and discloses a dark red, more or less disorganized pulp, occasionally running out as a semi-liquid mass. This engorgement is due chiefly to the presence of an enormous number of red globules. The liver is the seat of considerable disturbance. Its color is a yellowish brown. The parenchyma is deeply bile-stained, and when examined under the microscope the finest bile canaliculi are found plugged in many cases with consistent, cylindrical masses of bile. We have, in fact, a complete pathological injection of the intra-lobular biliary system. The bile in the gall-bladder is usually so thick that it scarcely flows. This is due to the presence of a large amount of solids in the form of minute yellow flakes. The kidneys in some cases are suffused with the color of hæmoglobin, and the connective tissue around them distended with reddish serum. Lesions of the fourth stomach were either absent or else did not differ in degree from those observed in healthy cattle. In one case there were superficial ulcers in the fourth stomach. A more or less extensive ecchymosis of the duodenum is occasionally met with, more rarely in the cæcum. In none of the eleven cases was there

any appreciable jaundice. The condition of those organs engaged in the destruction of red corpuscles, such as the liver and spleen, as well as the large quantity of blood pigment in the urine, led to the inference that the disease was primarily due to an enormous destruction of red corpuscles. Moreover, the absence of bacteria pointed to parasites in the blood different from these organisms.

When the investigations of the past summer were begun particular attention was paid to the blood. This led at once to the discovery of peculiar bodies within the red corpuscles. In fresh spleen pulp they are visible as round or oval, nearly colorless, spots, from one-half to 2 micromillimeters ($\frac{1}{50000}$ to $\frac{1}{12000}$ inch) in diameter on the disk of the red corpuscles, and always somewhat excentrically placed. Careful focusing leaves no doubt that they represent bodies within the corpuscles. There may be but one, quite commonly two, and very rarely three or four, in the same corpuscle. In organs kept in the cold for nearly two weeks they were still visible, but faintly, owing to the diffusion of the hæmoglobin around and perhaps into them. When cover-glass preparations are dried, heated, and stained with the ordinary aniline dyes, these intra-globular bodies stain as readily as nuclei and bacteria, and hold the stain with a similar tenacity. The smallest forms then appear like deeply-stained cocci, about one-half to 1 micromillimeter ($\frac{1}{50000}$ to $\frac{1}{25000}$ inch) in diameter, situated within the unstained circle of the corpuscle. Occasionally the bodies are nearer 2 micromillimeters ($\frac{1}{12000}$ inch) in diameter, and then the staining may be less dense. Besides the spherical forms ovoid forms are not uncommon. These usually occur in pairs within the red corpuscle. A still rarer pear-shaped form is encountered in stained preparations of the blood. It is rounded at one pole, while the other is pointed and sometimes drawn out as a short filament. These forms quite invariably occurred in pairs, a corpuscle being occupied by a single pair. I am very much inclined to consider the pair as the result of a division of the single body within the globule. One other abnormal form found in the blood deserves mention. When dried cover-glass preparations are stained in Löeffler's alkaline methylene-blue a few red corpuscles appear as if their surfaces had been dusted over with minute specks of coloring matter. Whether they are due to the anæmia or whether they belong to the cycle of the parasite remains to be determined experimentally. As to the relative number of intra-globular bodies in the different organs of the same animal, the eleven cases which have come under observation afford some noteworthy facts. As a rule there are very few in the circulating blood, whether taken from incisions through the skin before or during the death agony or from the heart after death. There are exceptions to this rule, however. In one case they were readily detected in the blood from a skin incision one day before the animal was killed. Blood from the right ventricle showed an enormous number of these bodies in pairs within the red globules. As a rule, then, the circulating blood contains comparatively few parasites. They are filtered out by the spleen and liver. They may be numerous in one or both of these organs, and rare in blood from the right ventricle. They are somewhat more numerous in the spleen than in the liver. This estimate may, however, be erroneous, wing to the larger number of corpuscles in the spleen pulp.

There are also a few facts at hand concerning the relative number of parasites in different animals at the time of death. In perhaps

one-half of the cases they were so few in number in the spleen that they might have easily escaped the attention of an observer searching for bacteria. In four out of eleven cases the organisms were very numerous in spleen and liver, and could not well be overlooked. They could be seen in a thin layer of fresh spleen pulp, with a dry apochromatic objective giving a magnification not more than 250 diameters. In one case they were so few in number even in the spleen pulp that a number of fields had to be scanned before any were detected. In this case the spleen was completely disintegrated. The urine, containing much hæmoglobin several days before death, was found of nearly normal color at the autopsy. The animal had evidently overpowered the parasites, but died from the havoc caused by them.

The second outbreak of the disease in October was fatal to but two animals. Of the remainder exposed only a few showed signs of disease; when, however, the blood of all the exposed was examined it was found that most of them were affected. The number of blood corpuscles had fallen to one-third or one-fourth of the normal, in one case to one-seventh. They presented all the appearances characteristic of Texas fever blood.

The nature of the bodies found within the red corpuscles can only remain a subject of conjecture at the present stage of the investigations, and it is evidently useless to present the various theories which we might hold in regard to them.

The work of the summer, besides having gotten under way experiments which are destined to clear up the external characters of the disease so mysterious and so unlike other known diseases of man or animals, has elucidated a few very important facts concerning the nature and diagnosis of the disease.

(1) It has demonstrated that Texas fever is essentially a blood disease, and that all the symptoms and lesions are referable to the destruction of red corpuscles. The disease may appear in two forms, an acute fatal and a mild form. The former, occurring in summer, is characterized by the sudden enormous destruction of corpuscles. The waste products resulting from this destruction clog up the liver, disintegrate the spleen, and lastly pass out unchanged through the kidneys, producing the "red water" or hæmoglobinuria. The mild form, occurring late in the season, is characterized by a moderate destruction of red corpuscles. The waste products are readily transformed without deranging the vital organs. The resulting anæmia gradually disappears as cold weather sets in.

(2) It has shown that this destruction of corpuscles is very probably due not to bacteria but to micro-organisms which are found within the red corpuscles and whose life history is still to be worked out.

(3) It will enable any microscopist to demonstrate either *during the life* of the diseased animal, by examining the blood and counting the red corpuscles, or immediately after death by examining microscopically the spleen or liver tissue, whether the disease is Texas fever or not.

(4) It has shown that animals may be suffering from Texas fever without manifesting any definite symptoms, and that the animal may erroneously be regarded well unless the blood be examined. This should be especially borne in mind by those carrying on "vaccination experiments."

ANTHRAX.

In June, 1889, Dr. Wray, an inspector of the bureau, brought from Mississippi two sealed tubes, one containing blood from a mule which had a large swelling on the under surface of the neck, the other containing blood from a cow which had succumbed to some disease. The blood in the tube from the mule had a very disagreeable odor and contained three different bacteria. They were not pathogenic and very probably contaminations.

The tube of cow's blood contained but one form, a bacillus. Its peculiar colonies on gelatine and agar, as well as its beautiful flocculent growth in the bottom of tubes of bouillon and its spore-formation, indicated at once that it was the true anthrax bacillus. Inoculation of two mice confirmed the diagnosis. One died within twenty-four hours with no marked internal or external changes. The spleen contained an enormous number of bacilli, the liver and blood less. The second mouse died in forty-eight hours, afflicted with an extensive subcutaneous œdema. The internal organs contained the anthrax bacilli in considerable numbers. Further investigations with this organism were not attempted, owing to the absence of facilities for conducting experiments with material dangerous to man.

The observations definitely prove the existence of anthrax in the Lower Mississippi Valley.

GLANDERS.

During the year the investigations in glanders were continued partly for the purpose of enlarging the work done in 1888 on the same subject, already published in the report for that year, and partly to confirm the diagnosis made by the veterinarian (Dr. F. L. Kilborne) on suspected horses in the District of Columbia. The investigations confirm those of last year without bringing to light any facts that deserve mention in this place.

INTERSTITIAL PNEUMONIA IN CATTLE.

During the past three years, three lungs came to the laboratory in which only the pleura and the interlobular tissue were affected. The parenchyma was normal, or at most slightly œdematous. The interlobular tissue was represented by firm whitish bands from one-eighth to one-half an inch in diameter. In these bands were cavities varying from the size of a pin's head to a large pea and communicating with one another. Some were empty, some filled with a mold of material similar to that of the bands themselves; some contained a rather thick, semi-liquid, grayish mass. The exudate forming these honeycombed bands was partly cellular, partly fibrinous, in character. The disease of the pleura was the same as that affecting the interlobular tissue.

Of the history of these cases nothing definite could be obtained. The importance of determining whether there are types of lung disease closely simulating the lesions of pleuro-pneumonia, as these did, led to bacteriological investigations of these three cases. In all a micrococcus was found (in the first case none other in fact) in the interlobular exudate, which closely resembled the swine plague germ. The general distribution of this germ throughout the exudate in differ-

ent parts of the lung leads to the inference that it was the cause of the disease. Its pathogenic properties confirm this view. Subcutaneous inoculation destroys rabbits in less than twenty-four hours.

Injection of bouillon cultures through the chest wall into the lungs of two calves produced a septicæmia fatal in less than twenty-four hours.

The bacteria can not be distinguished from those of swine plague, excepting, perhaps, in one particular. In bouillon cultures not more than twenty-four hours old a distinct capsule may be seen around each germ when the culture is examined fresh in a hanging drop. The bacteria on the edge of the drop do not touch one another, and the capsules can be distinctly made out as the cause of this separation. In subsequent cultures they are not to be seen.

The significance of this disease and the bacteria associated with it, as well as its relation to pleuro-pneumonia, can not be interpreted with the aid of the meager material and the incomplete histories of the cases examined. The lesions suggest pleuro-pneumonia, while the presence of specific bacteria separates this disease from pleuro-pneumonia in which no bacteria have hitherto been found. It is not improbable that the isolated and rare occurrence of this affection constitutes it a disease of septic origin. The localization of the disease points to an infection from the blood and lymph channels and not from the air. The bacteriological observations briefly sketched will enable us in the future to differentiate this lung disease from pleuro-pneumonia, provided the disease is at its height when the animal is killed and the lung perfectly fresh when presented for examination.

TUBERCULOSIS IN DOMESTICATED ANIMALS.*

Tuberculosis is an infectious disease of man and the lower animals, the term infectious being applied to all diseases due to the presence of micro-organisms. It is moreover an infectious disease of the contagious type; that is, it is communicable from one person or animal to another. The infectious nature of tuberculosis was, however, not fully recognized until demonstrated by Villemin in 1864. He showed that the inoculation of the cheesy matter found in the tubercles was followed by the appearance of similar tubercles in the inoculated animals, in other words, by the disease itself. Perhaps the most important advance in our knowledge of the disease as a whole was the discovery of the *bacillus tuberculosis* by R. Koch, in 1882. Before this time there existed much difference of opinion concerning the identity or non-identity of tuberculosis in man and in the lower animals. The discovery of the same bacillus in the various forms of the disease in man and animals practically settled this question, and it is now generally believed that tuberculosis in man and in the domesticated animals is the varied expression of the same disease.

The wide distribution of the disease among cattle, as well as the large percentage of animals diseased, has led to a great activity in the study of the disease in all its bearings. The most important questions now before the public are: (1) How can the disease be restricted among the domesticated animals? (2) Are human beings infected by consuming the flesh and milk of tuberculous animals, and

---

*Consult also Dr. James Law's report on tuberculosis as discussed at the International Veterinary Congress held at Brussels in 1883. First annual report of the Bureau of Animal Industry (1884), p. 350–366.

if so, to what extent? Before briefly discussing these two practical questions a few preliminary subjects demand our attention.

THE GENERAL CHARACTER OF THE DISEASE.

As its name implies, the disease is characterized by the formation, in different organs of the body, of certain nodules or tubercles of varying size. They consist of cellular elements crowded together, and owing to the absence of blood vessels they soon die for want of nutriment, and are converted into cheesy masses often impregnated with calcareous particles. The increase in size of these tubercles crowding upon and destroying the surrounding tissue of the internal organs, and the subsequent breaking down into cheesy matter, may be considered the chief injury inflicted upon the body by the disease. The tubercles are not limited to any particular region or organ of the body. Though they seem to show predilection for certain organs, which predilection varies with the species of animals affected, they may appear in almost any organ. Often beginning in some one locality, the tubercles there formed enlarge, become cheesy, and the virus lodged in this cheesy substance may be carried into other regions of the body. Sometimes the tubercle discharges the cheesy matter into a blood-vessel. It becomes disseminated throughout the body by the circulating blood, and wherever it lodges a new crop of tubercles appear in course of time.

The infection residing in the tubercle is due to a bacillus discovered by R. Koch in 1882, and demonstrated by him as the specific cause of the disease. This bacillus is a slender rod-shaped body, from $\frac{1}{17000}$ to $\frac{1}{7000}$ of an inch long, differing in certain respects from all other bacilli thus far discovered. It is found within the tubercle in greatly varying numbers, and is detected by special microscopical and bacteriological methods. Within the tubercle the bacilli form certain resistant bodies called spores. These enable the organism to resist various destructive agents, such as heat and cold, moisture, dryness, and putrefaction for a variable length of time. Koch has demonstrated, and after him many others, that the bacillus found in the various forms of tubercular disease in man and animals may be cultivated on blood serum at the body temperature. The bacilli grown outside of the body from different animals present the same appearance, and when animals are inoculated with them the same disease is produced by all. This disease has all the characters of the original disease from which the tubercle bacilli were obtained. The proof is thus satisfactory that this particular bacillus causes tuberculosis in man and animal.

THE DISEASE AS MANIFESTED IN MAN AND DOMESTICATED ANIMALS.

The disease in *man* presents various forms, the most common being tuberculosis of the lungs, known as phthisis or consumption. It may appear in various other organs. The condition known as scrofula in children has been demonstrated to be a form of tuberculosis involving the lymphatic glands. In the very young tuberculosis of the mesenteric glands is not uncommon, and it has been ascribed to infected milk from tuberculous cows. The tubercle bacilli are coughed up from the diseased lungs in large numbers, in the expectoration or so-called sputum, especially in the advanced stage of phthisis. This sputum is thus endowed with highly infectious characters, and is to-day considered by many authorities as the

chief agent in the spread of the disease. Statistics seem to show that at least 10 per cent. of mankind perish from tuberculosis. Monkeys living in the confinement of zoological gardens usually die of tubercular lung disease resembling the human disease very closely.

Tuberculosis in the horse is a rare disease, and the cases on record very few. It is not unlikely that owing to the similarity of tubercular and glanderous lesions it may have been occasionally mistaken for glanders. The disease is said to resemble, in a general way, that in cattle. It may appear in the lungs, on the serous membranes (*i. e.*, the smooth lining of the ribs, the covering of the lungs, and the smooth lining of the abdominal cavity), and in other organs. In the lungs the tubercles vary in size from a millet-seed to a walnut, not infrequently with cheesy contents. The bronchial glands (those clustered on the trachea and its two branches) may reach the size of a fist. Tubercles also may appear in the liver, spleen, and bones.

Trasbot* reports two cases, one examined in 1878, the other in 1884. The disease was very slow and insidious in its development, accompanied towards the end by great emaciation, cough, and irregular fever. At the autopsy large numbers of nodules and tubercles were found disseminated through the spleen and the lungs. These organs were very much enlarged. The tubercle bacilli were found in the diseased organs.

Nocard,† in reporting a case of tuberculosis in the horse, refers to the fact that he had mistaken this disease for *Lymphandénie pulmonaire.* He referred to at least seven cases of this disease reported between 1878 and 1882. In examining alcoholic preparations of these cases he was able to demonstrate the tubercle bacillus in every case. The differences between tuberculosis of the horse and that of other animals in part explained the error into which he had fallen. The neoplasm or tubercle in the horse is homogeneous throughout; there is no caseation and hence no formation of cavities. The ordinary signs of lung disease are absent, and there is no discharge from the nose. The cases usually occur isolated, although the animals come from large stables. The lesions seem to indicate that the disease begins in the abdominal organs and that the lungs are invaded later.

During the past few years more cases have been reported, and inasmuch as the diagnosis is not made at present without examining the tuberculous products for the presence of tubercle bacilli, we may be certain that tuberculosis is after all not so uncommon in the horse. Schortmann ‡ observed a case in which the disease apparently began as a pleurisy. The temperature and pulse fluctuated more or less; there was considerable difficulty in breathing and gradual wasting away. After the disease had lasted for a little over a month the animal died. At the autopsy the lymphatic glands of the abdomen (mesenteric and retro-peritoneal) and the lung-glands (bronchial) were found very much enlarged and caseous. There were tubercles on the pleura and peritoneum and a large number in the lungs. It was supposed that in this case the virus entered the system both from the air passages and the intestines. Schindelka § observed a case in which the disease began with a bronchitis. Among the symptoms noticed were difficulty of breathing, cough, fluctuating tem-

* Annales vétérinaires, 1884, p. 922.
† Recueil de Médecine vétérinaire, annexe, 1885, p. 45.
‡ Deutsche Ztschr. f. Thiermed, XV (1889), 339.
§ Oesterr. Ztschr. f. wiss. Veterinärkunde, II (1888), 69.

perature, loss of appetite, and great weakness. The passage of large quantities of urine (polyuria), to which Nocard has called attention in tuberculosis of the horse, was also observed in this case. At the autopsy, besides the plastic pleuritis, the lungs were found studded with small tubercles. In this case the tubercle bacilli must have entered the system with the inspired air, so frequently the starting point in human tuberculosis.

A. Peters* reports a case of tuberculosis of the lungs in a pet dog which had acquired the filthy habit of eating the sputum coughed up by a consumptive member of the family. The dog was shot, and on examination the lungs were found diseased. The intestines were not examined, although this would have been very desirable. It is supposed by some that infection in dogs is not infrequently due to the consumption of human sputum. In one case three dogs belonging to a consumptive patient died of tuberculosis.

Nocard† found tuberculosis in a cat nine months old which did not eat raw meat, but was fed upon milk every day. The disease was limited to the abdominal organs, the intestines, mesenteric glands, spleen, and liver. Subsequently he met with another case. Bollinger found two cases of generalized (miliary) tuberculosis in the cat.

Tuberculosis among sheep is very rare. The few cases described may have been confounded with the tubercular diseases in sheep due to worms found in the lungs and large intestines. Among goats the disease has been determined by Lydtin and others, although with them, too, tuberculosis is infrequent. Lydtin‡ found the disease in three cases. The goats mingled with a herd of milch cows, and it was supposed that the disease was transmitted from the cows to the goats. The diseased goats became emaciated, the mucous membranes pale, a cough appeared, and the milk was reduced in quantity, which necessitated slaughter. The disease was limited to the lungs, in which were numerous tubercles. These were also found on the pleura covering the lungs and the ribs.

Tuberculosis in swine is certainly very rare in this country. The writer has not seen any lesions similar to those described as occurring in European swine in upwards of a thousand cases examined. It is probable that the manner in which pigs are fed and the source of the food may account for this absence of tuberculosis in American swine. At the same time much of what has been described as tuberculosis may be in reality the result of lesions caused by swine plague and hog cholera, both producing caseous changes in the lungs and large intestines respectively.

Swine may be infected by running with tuberculous cows and by consuming their tuberculous milk. As the disease is said to be most common among pigs less than a year old, the disease may also be induced in sucking pigs by the milk of tuberculous sows. Besides the caseous changes in lungs and intestines, upon the nature of which we may entertain some well-grounded doubts, true tubercles may appear on the pleura and peritoneum. In generalized tuberculosis tubercles are found in the spleen, kidneys, testicles, and lymphatic glands. As regards the frequency of tuberculosis among swine statistics are not very abundant. In Baden .02 per cent. of all swine slaughtered within a period of eight years were found tuberculous. In Berlin,

* The Veterinary Journal, XVIII, 1889, p. 394.
† Recueil de Méd. Vét. annexe, 1888, 537; *ibid.*, 1889, 66.
‡ Arch. f. wiss. u. prakt. Thierheilkunde, X (1884), 36.

of all swine slaughtered in 1883 and 1884, .5 to .9 per cent. were similarly diseased.

Among wild animals confined in menageries, such as lions, tigers, etc., tuberculosis is not uncommon. Even the lower vertebrates are not spared. Sibley* recently described tuberculosis in a snake (*Tropidonotus matrix*). It had been brought from Italy to a zoological garden, where it died after a confinement of several months. Scattered through the body were nodules of varying size containing tubercle bacilli.

Fowls and other birds have been found affected with tuberculosis. The reports of outbreaks seem to indicate that the disease is due to the introduction of the virus into the body with the food. The tubercular lesions are limited to the intestines and the liver, or they may involve the ganglia and the ovary. Johne† describes the appearance of tuberculosis among fowls fed by a consumptive woman. The sputum of this person was usually thrown upon the manure pile where the fowls had access to it. The symptoms were great emaciation and debility. The stomach and liver were tuberculous, the other organs rarely so. Examination of the diseased livers revealed the presence of great numbers of tubercle bacilli.

Nocard‡ also reported a very instructive case of tuberculosis among poultry, due to feeding upon the expectoration of a phthisical man. The latter had charge of the poultry yard, as his feebleness did not permit any hard work. Three months after he began to do this work the first fowl died, and in all about ten succumbed. An examination showed tuberculosis of the abdominal organs. The keeper himself had noticed the avidity with which they ate the sputum.

Subsequently Nocard§ found the disease among the fowls of a slaughter-house, which were being fed with the diseased organs of cattle which could not be sold in the market.

Of six hundred hens examined Zürn found sixty-two affected with tuberculosis. Besides hens, turkeys, pheasants, and partridges are occasionally found tuberculous. Sibley‖ found the same disease in an owl which had been brought from Africa and died after a confinement of several months.

Whether the disease is ever conveyed from one bird to another is highly problematical. The instances cited above, and the locality of the disease (intestines and liver), are quite sufficient to prove that in birds the disease is caused by eating material containing tubercle bacilli, and that this material is found in our surroundings, and comes from man or the higher animals.

TUBERCULOSIS IN CATTLE.

This is unquestionably the most important phase of the subject. The disease in its various manifestations has been known for many centuries, and legislative enactments having reference to the destruction of affected animals and forbidding the use of the flesh thereof date far back into the Middle Ages. The opinions entertained regarding the nature and the cause of the malady varied much in different periods and very markedly influenced the laws and regulations in vogue. Thus in the sixteenth century the disease

*Arch. f. path. Anat., CXVI (1889), 104; Journ. Comp. Med. and Surg., 1889, 318.

†Deutsche Ztschr. f. Thiermed., X ('84), 155.

‡Recueil de Méd. Vét. (1885) annexe, 93.

§Compt. rend. Soc. Biologie (1885), 601.

‖*Loc. cit.*

was considered identical with syphilis in man. In consequence of this belief very stringent laws were enacted, which made the destruction of tuberculous cattle compulsory. In the eighteenth century this erroneous conception of the nature of the disease was abandoned and all restrictions against the use of meat were removed. Since that time, however, the tide of opinion has again turned against this disease. The particular opinion held at any time concerning the nature of this disease usually furnished for it a name. There are in most languages, therefore, a large number of peculiar terms which have accumulated, but which do not concern us here.

The cause of the disease in cattle, as perhaps in all other species, may be considered as twofold in its nature—the tubercle bacillus and certain predisposing causes which prepare the way for it. The ways in which the tubercle bacillus may be introduced into the body are various. The germs may enter the lungs by inhalation or they may pass into the body with the food. The frequency with which tuberculosis is found localized in the lungs of cattle indicates that they are in many instances the primary seat of the disease. The milk of diseased cows is a source of infection for sucking calves. Calves may be born tuberculous. In such cases the tubercle bacillus passes from the mother to the fœtus during gestation. Tuberculosis has even been found in fœtuses during the early months of fœtal life. It has likewise been maintained that tuberculosis may be communicated from one animal to another during coition. It is more difficult to understand how the tubercle bacilli are transmitted from one animal to another in stables and on pastures, since there is little if any discharge of bacilli, such as occurs so abundantly in human phthisis from the diseased lungs. At the same time it has been frequently noticed that the introduction of a tuberculous cow was followed by the infection of other animals in the same stable.

The causes which may be considered as predisposing are varied in character. Unsanitary conditions, such as overcrowding in poorly ventilated and poorly lighted stables, and feeding of food which is not nutritious, are not insignificant in this respect. Conditions which injure the lungs are favorable to the development of tuberculosis. Among these are the inhalation of dust and smoke, and all conditions which may induce chronic inflammation of the bronchial tubes, with abundant secretion and subsequent pneumonia (broncho-pneumonia). Among the other causes which are said to favor tuberculosis is the overproduction of milk, too many births, the improvement of stock by continual inbreeding and the consequent inheritance of certain constitutional characters of a debilitating nature.

These predisposing causes determine to a great extent the occurrence of the disease. Thus animals living in the lowlands are more subject to this disease than the more robust races living in elevated mountainous regions. Similarly animals on the open pasture are less susceptible than stabled animals. This may, however, be due to concentration of virus in the stables. The disease is likewise far more common in cows than in oxen, owing to the strain which bringing forth young and milking subject the females. Animals subjected to special feeding, such as dairy cows, cows in distilleries, breweries, and other manufactories having waste available as food, are the most susceptible to the disease. The distribution of tuberculosis in general is also governed by climate and other meteorological factors, as well as by the amount of infection. As regards the latter it is well known that the greatest number of cases occur in the immediate en-

vironment of cities where virus may be regarded most abundant. The disease is said to be rare in northern countries, such as in the north of Sweden and Norway, on the Steppes among wild herds, on islands such as Sicily and Iceland.

Statistics indicate that the percentage of cattle attacked varies greatly. From tables compiled by Göring for Bavaria,* we learn that in 1877 and 1878 the number of tuberculous cattle was .16 per cent., or about 16 head in every 10,000. The disease was distributed in accordance with age and sex as follows:

	Per cent.
In 1,000 steers	5.84
In 1,000 oxen	1.39
In 1,000 cows	2.50
In 1,000 young animals	.35
In 1,000 calves	.00

According to age the disease had attacked 64 under one year, or 1.31 per cent. of all those diseased; 328 from one to three years old, or 10.81 per cent. of all those diseased; 1,846 from three to six years old, or 37.80 per cent. of all those diseased; 2,445 over six years old, or 50.07 per cent. of all those diseased.

Statistics of tuberculosis among cattle slaughtered in the larger cities of Germany, collected during the years 1879 and 1880, give a percentage ranging from 1.25 to 3.4 per cent.

In Baden, where meat inspection is regularly practiced in all the communities, and where quarterly reports are handed in to the district veterinarians, it was found that there were but 8 tuberculous animals in 1,000, and in those communities where chiefly cows were slaughtered the number rose to 15 in 1,000.

Among the more recent statistics carefully compiled at the places of slaughter, the following may find a place here. At Göttingen, Germany, out of 1,784 head of cattle slaughtered from April, 1886, to April, 1887, 18, or about 1 per cent., were tuberculous. Of 5,981 calves only one was tuberculous. At Munich, during 1886, 2.75 per cent. of all slaughtered cattle were tuberculous. At Augsburg, during the ten years beginning with 1877, 2.91 per cent. were found tuberculous. In Dresden, during 1886, 1.6 per cent. of the adult cattle and .15 per cent. of the calves were affected with this disease. At Zittau one herd contained 26 per cent. of tuberculous animals. In Nürnberg, during 1886, 33 out of 11,255 oxen, or about .3 per cent., were tuberculous; of 1,621 steers 2 were diseased; of 1,150 cows, 26, or about 2 per cent., were diseased. In France, according to figures given by Arloing, there are, on the average, 5 animals tuberculous in every 1,000, or about one-half per cent. In the various cities of France the figures obtained by inspectors at the abattoirs vary from 1.43 to 14.5 per 1,000, the observation extending over a period of one to five years. In Belgium, according to Van Hertsen, the rate is 4 per cent. In Holland it varies from 4 to 19.6 per 1,000. In England, according to Cope, it varies from 1 to 26 per cent., according to the locality.† At Copenhagen, according to Bang, during 1888 the rate was 6 per cent.; for cows alone it rose to 16 per cent. In the Argentine Republic, according to Even, tuberculosis seems to attack the recently imported improved stock (10 to 15 per cent.), while it is comparatively rare among natives (one-half per cent.).‡ In Algiers, ac-

* Lydtin, Archiv. f. wiss. u. prakt. Thierheilkunde, x (1884), 28.
† Veterinary Journal, 1889, 398.
‡ Recueil de Méd. Vét., 1889, 598.

cording to Texier,* the disease is very rare; only 7 cases (5 old cows, 1 old oxen, 1 sucking calf), or about 1 in 10,000, were found in 72,623 animals slaughtered in 1884 and 1886, inclusive.

In our own country cattle slaughtered at Baltimore under the auspices of the Bureau of Animal Industry were found tuberculous to the extent of from 2½ to 3½ per cent.

It is evident that statistics obtained from slaughtered cattle must necessarily vary greatly. The territory from which cattle are obtained and the tendency to send unthrifty animals to the abattoir may artificially raise the percentage of tuberculous cattle, especially in our large cities. It is in the vicinity of large communities where the concentration of cows for dairy purposes bring into play the two factors necessary for the development of the disease, importation and concentration of the virus, and an increased predisposition, owing to an unsanitary environment and exhaustion of vitality, that we should expect to find the highest percentage of the disease.

CHARACTERS OF THE LESIONS IN BOVINE TUBERCULOSIS AND THEIR DISTRIBUTION IN THE VARIOUS ORGANS OF THE BODY.

The changes which are found in tuberculosis are limited in a large number of cases to the lungs and the serous membranes† of the thorax and abdomen. Pathologists have therefore called the lung disease tuberculosis, the disease of the serous membranes "pearly disease." Statistics have shown that in about one-half the cases both lungs and serous membranes are diseased, in one-third only the lungs, and in one-fifth only the serous membranes. At the same time the lymphatic glands near the diseased organs are usually involved. Other organs, such as the liver, not infrequently contain tubercles. Though the disease may remain restricted to a single organ, it now and then is found generalized, affecting all organs of the body.

In the lungs the changes observed vary according to the age and intensity of the disease process. They usually begin with the appearance of miliary tubercles. These are minute bodies not larger than a pin's head, firm, yellowish-white, opaque. They may appear in large numbers on the surface of the lungs or within the lung tissue. Later a change goes on within these tubercles by which the contents become cheesy and partly calcified. When these tubercles are sufficiently numerous to become confluent, larger masses or nodules are formed which may undergo the same retrogressive changes of caseation and calcification. In addition to the tubercles in the lung tissue certain other changes take place. There is usually present bronchitis with abundant catarrhal secretion. This plugs up the smaller air tubes, and the lung tissue supplied by these tubes with air collapses. Subsequently it becomes filled up with yellowish, cheesy matter, which greatly distends the small air tubes and air vesicles (broncho-pneumonia). The connective tissue between the lung lobules, around the tubercles and around the air tubes, becomes thickened and indurated. In the larynx and the bronchi, tubercles may vegetate upon the mucous membrane, and ulcers may result from their breaking down. The inflammatory irritation which the

---

* Études sur la tuberculose, 1887, I, 339.

† These comprise the smooth, very delicate, glistening lining of the large body cavities. In the thorax the serous membrane (pleura) covers the ribs and diaphragm as well as the whole lung surface. In the abdomen a similar membrane (peritoneum) lines the interior of the cavity and covers the bowels, liver, spleen, etc.

growth of the tubercles on the surface of the lungs arouses gives rise to adhesion of the lungs to the ribs and diaphragm. This adhesion is sometimes so firm and extensive that the lungs appear grown to the chest wall. When, therefore, the lungs in advanced stages of the disease are cut open, we observe large yellowish masses from one-quarter to three-quarters of an inch in diameter, of a very firm texture, in which calcified, gritty particles are imbedded and which are surrounded by very firm bands of connective tissue. The neighboring lung tissue, when collapsed and involved in broncho-pneumonia, has the color and consistency of pale-red flesh. The air tubes, large and small, stand out prominently on the cut surface. They are distended with a pasty, yellowish, cheesy mass, surrounded and enveloped in thick mucus, and their walls greatly thickened. The larger bronchi may be sacculated, owing to the distension produced by the cheesy contents.

The disease usually involves the bronchial glands which are situated on the trachea and bronchial tubes at the bifurcation. The changes in the glands are the same as those going on in the lung tissue, and they frequently reach an enormous size.

The tubercle formation on the serous membranes, which may go on at the same time with the lung disease or independent of it, has been called "pearly disease" on account of the peculiar appearance of the tubercles. These begin as very minute grayish nodules, which give the originally smooth, lustrous membrane a roughened appearance. These minute tubercles enlarge, become confluent, and project above the surface of the membrane as wart-like masses reaching the size of a pea. These may be closely sprinkled over the membrane and be situated on the lung surfaces, the ribs, the diaphragm, in the abdominal cavity on the walls, and on the omentum (caul). But they may grow much larger and attain the size of hens' eggs. The manner in which the smaller tubercles group themselves into a mass gives the latter a variety of shapes. They likewise undergo retrogressive changes. The center partly softens, partly calcifies into a grayish mortar-like mass, and when cut into they feel gritty. Associated with the formation of tubercles on the pleura those glands situated back of the lungs (posterior mediastinal) become greatly enlarged and the center cheesy. They may compress the œsophagus and interfere with swallowing. The size attained by these tumors and new growths is well illustrated by the fact that taken together they not infrequently weigh from 60 to 80 pounds. The bronchial glands, which in the healthy state are not as large as horse-chestnuts, have been found to attain a weight of over 10 pounds.

In the abdominal cavity tubercles may appear in the liver. Here they vary in size from a pea to a hen's egg, and usually appear on the surface, projecting above it and dipping down into the liver tissue. The smaller ones are firm, smooth, or lobulated; yellowish, gritty on section; the larger may be softened into a yellowish cheesy mass. The organ may become enormously enlarged and very heavy. Similar tubercles may appear in the spleen, the kidneys, the uterus, and the testicles. The ovaries are occasionally greatly enlarged by tubercular processes.

The lymphatic glands may enlarge on account of tubercular infiltration. This is true of the glands within the large cavities, as well as those which can be felt under the skin, such as the glands found at the joints of the limbs, under the jaws, along the neck, etc. The glands of the thorax have already been mentioned in this respect.

Those in the abdomen, such as the mesenteric glands, those near the liver, spleen, and kidneys may likewise become diseased.

Tubercular affection of the intestines seems to be quite rare, although ulcers of the large intestine have been observed. Nodules may also form under the serous covering of the intestines.

The brain and spinal cord are occasionally found tuberculous. Of forty cases, Semmer found tuberculosis of the brain in four. It is not improbable that, owing to the infrequency of exposing the brain and spinal cord, tuberculosis may have escaped the attention of pathologists, and it may be that it is not so uncommon as is generally supposed. The tubercles occur on the membranes of the brain as well as in the substance of the brain itself. They project into the ventricles as masses varying in size from a pin's head to a hen's egg. They finally lead to various inflammatory changes. Johne has observed numerous small tubercles on the membranes of the spinal cord.

Very rarely tuberculous lesions have been observed in the bones and muscles of the body.

Tubercular disease of the udder in cows has received considerable attention of late from sanitarians, owing to the infection of the milk with the virus of tuberculosis. According to those who have given this subject special attention, the udder becomes swollen uniformly and quite firm. This swelling, which is painless, frequently attacks but one quarter, more rarely two, these being usually the hind quarters. The larger milk ducts contain yellowish cheesy particles in which are many tubercle bacilli. Later on larger nodules can be felt within the udder, which undergo the various changes to which tubercles are subject. The udder may grow very hard to the touch and become very large, weighing in some cases up to 40 pounds. The milk, at first normal, becomes thin and watery after a month or so, and is mixed with flakes and numerous tubercle bacilli.

As regards the frequency of the tubercular processes in the different organs, the following carefully compiled statistics of the disease in Bavaria and Baden may serve as a guide:

	Per cent.
Bavaria:	
Tuberculosis of lungs and serous membranes	41
Tuberculosis of lungs alone	33
Tuberculosis of serous membranes alone (pearly disease)	17
Tuberculosis of other organs	8
Baden:	
Tuberculosis of lungs alone	21
Tuberculosis of serous membranes alone	28
Both combined	39
Generalized tuberculosis	9
Tuberculosis of the sexual organs alone	3

SYMPTOMS OF TUBERCULOSIS IN CATTLE.

The beginning of the disease usually passes unnoticed, inasmuch as it is very slow and insidious and rarely accompanied by fever. When the lungs are involved a dull short cough is noticed, which may later on become prolonged, convulsive, and very troublesome to the animal. The cough is more frequent in the morning after movement and drinking. The breathing varies; only when much of the lung tissue is diseased is it labored and accompanied by active movements of the chest and nostrils. Discharge from the nose is rare or absent. At times, however, when the tubercles have broken down and formed in the lungs cavities containing cheesy masses, or when

the air tubes have become filled with cheesy and mucous masses, coughing will dislodge these and cause their discharge. In advanced stages the breath may have a disagreeable odor. Pressure on the chest wall may give rise to pain.

The general effect on the body is at first slight. In fact, animals may remain in good flesh for a considerable time. Invariably, as the disease progresses, loss of flesh and appetite and paleness of the mucous membranes become manifest. These are accompanied by a gradual diminution of the milk secretion. The debilitated condition of the animal is also manifested by a staring coat and a tough, dry, harsh skin (hide-bound). Digestive disturbances are indicated by tympanites or distension of the rumen by gas, colic and diarrhea alternating with constipation. The animal generally dies from exhaustion after a period of sickness which may last months and years.

Tuberculosis in the abdominal organs is often signalized by abortion and by abnormal sexual manifestations. When the brain is involved the disease may cause convulsions, unconsciousness, paralysis, as well as peculiar movements in a circle, oblique position of the head, etc. Lydtin quotes the following description of the disease as taken from a Swiss sanitary order:

> A dry, short, interrupted, hoarse cough, which the sick animals manifest especially in the morning at feeding time, still more after somewhat violent exertion. At first these animals may be full-blooded and lay on a considerable amount of fat when well fed. As the disease progresses they grow thin and show more and more those appearances which indicate diseased nutrition, such as a staring, lusterless, disheveled coat; dirty, tense skin, which appears very pale in those regions free from hair. The temperature of the skin is below normal. The loss of fat causes sinking of the eyes in their sockets. They appear swimming in water and their expression is weak. The cough is more frequent, but never or very rarely accompanied with discharge. The body continues to emaciate even with plenty of food and a good appetite, so that the quantity of milk is small. At times, in the early stages of the disease, still more in the later stages, the diseased animals manifest considerable tenderness when pressure is applied to the front or the sides of the chest, by coughing, moaning, etc. Often all symptoms are wanting in spite of the existence of the disease.

Lydtin also quotes at length a description of the abnormal sexual desire occasionally observed among cows when affected with this disease.

A disease so varied in its attack upon the different organs of the body and in the extent of the disease process must necessarily lead to mistakes of diagnosis. It has been confounded with the later stages of pleuro-pneumonia, with parasitic diseases of the brain, the lungs, and intestines. A parasitic disease in cattle, quite common in this country, which is accompanied by tubercles under the mucous membrane of the small intestines, has been mistaken for tuberculosis. The tubercles vary in size from mere specks to peas. The larger ones contain a crumbling, caseous mass of a dirty grayish color. In many of them the worm causing the tubercle is still within, and may be detected under the microscope in the contents of the tubercle. The absence of tuberculosis of the lungs, pleura, and lymphatic glands in the animal is a pretty certain indication that tuberculosis does not exist.

Tuberculosis does not, as a rule, end in recovery, and treatment is useless. Preventive measures in this as in most other diseases are the only reliable ones. They consist in removing and isolating the suspected animals and in destroying them when there is sufficient evidence that tuberculosis exists. The milk of such animals should not be used in the feeding of calves, swine, and other domesticated

animals. Concerning the use of the flesh and milk for human food, some facts will be given further on. The carcasses of tuberculous animals should be carefully buried, or burned if possible. In short, the diseased animals and their remains should be regarded as a menace to the health of man and animals and treated accordingly.

BOVINE TUBERCULOSIS IN ITS RELATION TO THE PUBLIC HEALTH.

Tuberculosis being restricted more or less to thickly settled communities, and causing in general but slight losses when all the cattle of a country are taken into consideration, is not a very serious matter to the owner of cattle from a financial point of view. The interest which has been manifested in this disease is due to quite different causes. The identity between human and animal tuberculosis, combined with the extraordinary mortality of human beings from this disease, often amounting from 10 to 14 per cent., has raised the question in all civilized countries as to how far animal and especially bovine tuberculosis was to blame for this high mortality. The medical and veterinary professions have approached this problem with equal zeal, and much has come to light within recent years which enables us to come to some conclusion. If the disease is transmitted from animals to man how does the transmission take place? As very few people come in direct contact with tuberculous cattle, it must be if at all either through the meat or the milk, or through both, that the virus enters the human body. The question has thus narrowed itself down to the food products furnished by cattle.

Is flesh from tuberculous cattle the bearer of infection?—This question has become a very urgent one in the Old World, since meat is a scarce and expensive article of food. It is argued there that if it can be shown that in the majority of cases of tuberculosis the muscular system is free from infection, there is no reason why the meat should not be put on sale under certain restrictions. The question may be resolved into two divisions: (1) How frequently does the disease invade those parts of the body which are used as food? (2) When the disease process is manifestly restricted to the internal organs do tubercle bacilli circulate in the blood and lymph, and can they be detected in the muscular tissue?

(1) Disease of the bones is not unknown, although very rare. According to Walley it appears chiefly in the spongy bones of the head and backbone and in the long bones of the limbs. Occasionally the ends of the bones, where they are covered by the synovial membrane of the joints, are dotted with tubercles. The muscular system itself is very rarely the seat of tubercular deposits, although the lymphatic glands lying near and among the muscles may be not infrequently diseased.

(2) Whether tubercle bacilli are found in muscle juice independent of any tubercular deposits is a question which must be approached experimentally. There is on record a great variety of opinion on this matter, some authorities considering all flesh from tuberculous animals unfit for food, while others hold a contrary view. Such opinions are, however, worth little unless backed by positive evidence, such as is afforded by direct inoculation of animals susceptible to tuberculosis. The diametrically opposite views of the older authorities are due partly to the fact that they fed the material to be tested to different species of animals, some of which are now known to be insusceptible to such feeding, partly because nothing was

known of the presence or absence of the tubercle bacilli in the material fed. It is well known among pathologists to-day that there is much variation in this respect Tuberculous growths may contain enormous numbers of bacilli or they may contain but very few. Their number seems to vary with the age of the disease process, with its location, and the species of animals from which the tuberculous matter is obtained. Moreover, feeding even susceptible animals is at best a method of doubtful utility, upon which little reliance can be placed. There are, however, a few experiments on record which can be considered trustworthy, inasmuch as they were made according to the approved method of injecting the suspected material directly into the peritoneal cavity of guinea-pigs.

Kastner,* under the direction of Bollinger, inoculated animals with the juice expressed from the flesh of tuberculous animals. The flesh of twelve cows was used for this purpose. Sixteen guinea-pigs received of the meat juice from 1 to 2 cubic centimeters each into the peritoneal cavity. All remained healthy.

Nocard† expressed the juice of the heart muscle taken from tuberculous cattle and injected from 10 to 20 drops into the peritoneal cavity of guinea-pigs. Eleven cows in an advanced stage of consumption were employed for this experiment. None of the inoculated guinea-pigs showed signs of disease.

Subsequently he‡ repeated this experiment with ten tuberculous cows. The juice of muscular tissue from one of the thigh muscles was expressed and 1 cubic centimeter injected into the peritoneal cavity of guinea-pigs, four being used for each case. Of the forty animals thus inoculated only one became tuberculous. These experiments led Nocard to formulate the following conclusions:

(1) The flesh of tuberculous animals may in certain instances present some danger.

(2) But it is very exceptionally dangerous.

(3) In those cases in which it is dangerous it is always so in a very slight degree.

But all experiments are not equally negative. Chauveau and Arloing inoculated ten guinea-pigs with the juice expressed from the muscles of a diseased ox. Of these two became tuberculous. Six guinea-pigs, inoculated with the meat juice from another case, remained well. Galtier obtained five positive results out of twenty-two series of inoculations. Arloing concludes from these various observations that the flesh of one out of every ten tuberculous bovines contains tubercle bacilli demonstrable by inoculation.§ The stage of the disease no doubt determines to a great extent the presence or absence of tubercle bacilli in the muscular tissue. In cases far advanced they may be more abundant and hence more easily detected. Thus Steinheil‖ inoculated guinea-pigs from the flesh juice of nine persons who had died in an advanced stage of tuberculosis. Positive results were obtained in every case.

The milk of tuberculous cows.—Concerning the infectious nature of milk secreted by tuberculous cows, authorities have universally agreed that when the udder itself is in the slightest degree involved the milk possesses infectious properties and is therefore dangerous.

* Münchener med. Wochenschr., 1889, 583.
† Recueil de Médecine vét. annexe, 1885, p. 49.
‡ Recueil de Méd. vét., 1888, p. 574.
§ Congrés pour l'étude de la tuberculose, 1888, 64.
‖ Münchener med. Wochenschr., 1889, No. 40, 41.

Tubercle bacilli have been found in large numbers in the milk and the udder under such circumstances. Unlike other affections of the udder, tuberculosis of this organ does not at once change the appearance and the quality of the milk secreted. Bang states that for at least a month after the disease has appeared the milk is normal in appearance and may be consumed and sold without arousing the suspicion of the owner. There is therefore considerable danger involved in this disease, and the necessity for the careful inspection of dairy cows seems more urgent than ever before.

Authorities are, however, not fully agreed as to whether the milk from tuberculous cows in which the udder is apparently not invaded by the disease should be considered dangerous or not. Some are inclined to believe that the milk secreted by healthy udders is never infectious even when the lungs or other organs are affected; that, in other words, the tubercle bacilli are rarely, if ever, separated from the lesions which they produce, that the udder itself must be diseased before tubercle bacilli can appear in the milk. Experiments made with the milk of tuberculous cows in which there were no indications of udder disease do not bear out this theory, as the statistics to be given below will show. Tubercle bacilli have been found in the milk of such cows. Some authorities, among them Nocard, still believe that the udder is diseased when the milk is infected, but that the disease escapes observation. However this may be, the fact that the udder may be diseased and the disease not recognizable simply casts suspicion upon all milk from tuberculous animals. That this suspicion is not without foundation some recent investigations may be here briefly summarized as evidence.

Under the auspices of the Massachusetts Society for the Promotion of Agriculture, Dr. H. C. Ernst, assisted by Dr. A. Peters, made some experiments to test the character of the milk from tuberculous cows having no recognizable udder disease. The milk was examined microscopically and the tubercle bacilli demonstrated in the milk of ten out of thirty-six cows, or 27.7 per cent. Guinea-pigs also were inoculated with the milk from fourteen cows, and from the milk of six of these, or 42.8 per cent., the inoculation was successful.

Hirschberger, under Bollinger's direction, made a number of experiments to test the infectious properties of milk from tuberculous cattle. Of twenty cases the milk of eleven (55 per cent.) produced tuberculosis, when injected into the peritoneum of guinea-pigs in quantities of 1 to 2 cubic centimeters ($\frac{1}{500}$ to $\frac{1}{250}$ pint). Of five cows highly tuberculous the milk of four was infectious; of six cows moderately tuberculous the milk of four was infectious; of nine cows slightly tuberculous, the disease being restricted to the lungs, three gave infected milk. Only in one specimen of milk were the tubercle bacilli discovered under the microscope.

The following experiments indicate a much smaller percentage of infection:

Nocard* inoculated guinea-pigs with milk from eleven tuberculous cows. Of these only one had the udder diseased. The guinea-pig inoculated from the milk of this animal died of generalized tuberculosis; the rest remained well.

Bang† injected into the abdominal cavity of rabbits from 1 to 2 cubic centimeters of milk from twenty-one cases of advanced tuber-

---

* Recueil de Méd. vét. annexe, 1885, p. 49.

† Congrès pour l'étude de la tuberculose, Paris, 1889.

culosis in which the udder appeared normal. Positive results were obtained from but two of these cases.

Concerning the infection of swine with milk from tuberculous cattle the following interesting statement is worth quoting:

> The owner of a valuable herd of cows, finding that a large proportion of them were tuberculous, so large a proportion indeed as strongly to suggest infection by association in the sheds, withdrew his milk from the market and used it, unfortunately without boiling, for fattening his pigs, of which he has a large number and on which he prides himself not less than on his cows. The result has been that the pigs have, almost without exception, been affected with the disease to an extent that has necessitated the slaughter of the whole stock. Another point of practical interest is that he has not been able to discover nodules or other indications of localized tubercle in the cows' udders, a condition still held by some to be necessary to render the milk capable of transmitting the disease.*

Bollinger† has shown that it is more dangerous to consume the milk of a single cow for a period of time than to take the mixed milk from many animals. Any virus contained in the milk of one cow is thus greatly diluted, and the few bacilli consumed may be harmless. Thus guinea-pigs inoculated with mixed milk generally remained well. Infected milk lost its virulence in one case when diluted with forty parts of water; in another when diluted with fifty parts; in still another the milk did not lose its infectious properties until diluted with one hundred parts.

In comparison with this rather feebly infectious character of milk human sputum was found exceedingly infectious. A dilution of one hundred thousand times did not rob it of its infectious character.

If any positive conclusion could be arrived at from the small quantity of evidence now on hand it would be to throw suspicion both upon the flesh and the milk of tuberculous cattle. These products in any given case may be free from infection or they may not be. As Bollinger has shown, the tendency to mix the milk in dairies may dilute the infection proceeding from any one cow so much as wholly to neutralize it, provided the number of diseased cows is proportionally very small. Fortunately we have at our command a ready means of destroying any suspected virus in the milk. Boiling for five or ten minutes is sufficient. Similarly the dangers possibly inherent in meat are overcome by the heat to which meat is usually exposed in its preparation for the table. This appears sometimes insufficient in rare meat, but even then the tubercle bacilli may be so much attenuated as to become powerless for evil. The dangers inherent in milk are greatest for children, who are more susceptible, and whose food during the earlier years of life is made up largely of milk.

THE PRESENT STATUS OF LEGISLATION IN FOREIGN COUNTRIES ON BOVINE TUBERCULOSIS.

The attention of the various governments of the European States has been for several years directed to this subject of bovine tuberculosis on account of its bearing upon the health of mankind. Very little has yet been done in the form of legislation, owing to the hitherto unsettled or incomplete knowledge on the part of recognized medical and veterinary authorities. This, however, no longer exists, and there is a strong unanimous sentiment over the civilized world that something must be done to keep the evil in check. In 1888 a congress for the study of tuberculosis was held in Paris. At its sessions the relation of bovine to human tuberculosis formed a prominent

* British Medical Journal, 1889, I, 30. † Münchener Med. Wochenschr., 1889, 73 L.

part of the discussion. It likewise was the important topic discussed at the International Veterinary Congress held in Brussels in 1883 and in Paris in 1889. It is the important topic in all societies devoted to sanitation and public health, and great pressure is being exerted through these bodies as well as in the medical press upon the various governments to take hold of this subject.

In France the veterinary associations have long since demanded that tuberculosis be classed with the contagious diseases of animals. This was done by a decree dated July 28, 1888. The ministerial order of the same date contains the following prescriptions:

ART. 9. When the existence of tuberculosis has been established in cattle, the prefect issues an order placing these animals under the care of a sanitary veterinarian.

ART. 10. Every animal known to be tuberculous is isolated and sequestrated. The animal can only be moved for slaughter. The killing is done in the presence of the veterinarian who is to make the autopsy, and send to the prefect the protocol within five days after the autopsy.

ART. 11. The flesh of tuberculous animals is excluded from consumption (1) when the lesions are generalized, *i. e.*, not confined exclusively to the internal organs and their lymphatic ganglia; (2) when the lesions, although localized, have invaded the greater part of a single organ, or manifest themselves by an eruption on the walls of the chest or abdomen. This meat, excluded from consumption, as well as the tuberculous organs, can not be used to feed animals, but must be destroyed.

ART. 12. Utilization of the hides is only permitted after disinfection.

These regulations, according to Vallin, will at least prevent the slaughter of all consumptive cattle in private places beyond reach of all control, and the transformation of the flesh into "foreign" meat, smuggled into the markets of the cities. It will also prevent the movement of such cattte into the markets to be sold, after many stables in which the animals have lodged have been soiled and infected by them.

In England* the diseases of tuberculosis and pleuro-pneumonia among cattle were referred to a departmental committee, who sat during April, May, and June, of 1888. A considerable number of witnesses were examined. Some of the recommendations of the committee are as follows:

Legislation directed to the protection of cattle from tuberculosis should, at the same time, include such measures as will also prevent its communication to man.

In the first place, the question of curative treatment may be dismissed in a few words, except in those cases (almost entirely confined to the human being) where it is only locally manifested, and in which, consequently, its foci can be excised and removed by surgical treatment.

This being so, it is evident that legislation must follow two lines of—

A. *Prevention.*

B. *Extirpation.*

A. *Preventive measures.*—These should include provisions for *improved hygiene of cattle sheds*, etc. (especially in the direction of providing proper ventilation, pure water supply, and adequate disinfection of stalls, etc., wherein tubercular animals have been kept). This has been partly met in the Dairy and Milk Shops Order, but its administration by the local health authorities is at present imperfect, and we would suggest that it should be much more stringently enforced, and that veterinary inspectors should be given more extended powers of entry into all places where animals are kept.

Improvement in the hygienic surroundings of animals should include isolation of all suspected cases, precautions against the flesh or milk of diseased animals being given as food to others, *e. g.*, to pigs, fowls, etc., and care that fodder, litter, and water should not be taken from one animal or stall to be given to another.

Our attention has been drawn to the frequency with which animals, obviously diseased, sometimes even in the last stage of the malady, are sold in open market. Although in England and Ireland, under the provisions of the nuisance removal

*Annual Report, Agricultural Department, for 1888.

act, as embodied in the public health act, 1885, the medical officer of health or inspector of nuisances may seize such animals, yet such seizure is rarely performed.

We find the veterinary inspector has no power to prevent such sales or to seize the beast for slaughter, since tuberculosis is not included in the contagious diseases (animals) act of 1878.

We further find that there is actually a regular trade in such stock infected with tuberculosis, and that they go by the name of "wasters" and "mincers," being frequently slaughtered in the neighborhood of the larger towns, to which such portions of the meat as are likely to escape the observation of the inspector of nuisances are sent for the purposes of sale among the poorer inhabitants and especially for the making of sausages.

We are therefore very strongly of opinion that power should be given to the veterinary inspector to seize all such animals in fairs, markets, or in transit. * * *

Since all authorities are agreed that the disease is very marked by heredity, we think it highly desirable that breeders should, in their own as well as in the public interest, discontinue breeding from tuberculous stock.

B. *Extirpation.*—In order to insure the gradual extirpation of tuberculosis, we are of opinion that it should be included in the contagious diseases (animals) acts for the purposes of certain sections of those acts, so as to provide:

(*a*) For the slaughter of diseased animals when found diseased on the owner's premises.

(*b*) For the payment of compensation for the slaughter of such animals.

(*c*) For the seizure and slaughter of diseased animals exposed in fairs, markets, etc., and during transit.

(*d*) For the seizure and slaughter of diseased foreign animals at the place of landing in this country. * * *

Professor Brown, in commenting on these recommendations, points out a number of difficulties which would oppose the successful execution of a law embodying them. Among these are the difficulty of distinguishing tuberculosis in cattle from actinomycosis, lymphadenoma, diseases of the udder, and rheumatism with enlargement of the joints in young cattle. It is also difficult to make an *ante-mortem* diagnosis, and this difficulty would become very serious in case of valuable pedigree stock. In short, the difficulties were sufficient to prevent the passage of the Order of Council prepared on the lines of the committee's report. Meanwhile the question of what to do with the flesh from tuberculous cattle is in a very unsettled condition. Cases are constantly coming up for decision before the magistrates. These decisions are not uniform, however. Thus, in Belfast* one judge ordered the destruction of the carcasses; two others sitting several weeks later refused to give an order for the destruction of two carcasses which were clearly shown to have been diseased with tuberculosis.

The British Medical Journal, in commenting on this condition of things, says:

What we want and what the medical profession must fight for is a definite system of control, placed in the hands of thoroughly qualified, inspectors who shall have full power to condemn without appeal and destroy all meat that they may consider unfit for human food.

In the German Empire bovine tuberculosis has not, up to the present time, been included among those animal plagues upon which extensive statistical reports are being issued annually. This exclusion is not due, however, to any lack of interest in this matter or to unbelief in the dangers and perils to public health lurking in the untrammeled existence and spread of the disease; for Germany, in her scientific researches and in the attitude of the medical and veterinary fraternities, has been foremost in promulgating the doctrine of the essentially contagious nature of tuberculosis. The obsta-

*British Med. Journal, 1889, Nov. 2.

cles to any legislation thus far have been those cited by Professor Brown, of England—the difficulty of detecting the disease during the life of the affected animal, and insufficient knowledge of its nature and extent. In consequence of numerous petitions from all parts of the Empire, expressing the wish that something be done to check the spread of bovine tuberculosis, the Chancellor of the Empire, on October 22, 1887, issued a circular * to the different States for the purpose of obtaining as complete statistics as possible on the present status of the disease. These statistics were to include (*a*) the number of cases of tuberculosis in slaughtered cattle, as determined in public and private abattoirs by the meat inspectors, as well as the total number of cattle slaughtered; (*b*) the number of cases of tuberculosis in living animals as determined at markets, in dairies, etc., as well as in the private practice of veterinarians. At the same time the existence of the disease was to be indicated as definite, probable, or suspected, as the case might be. Special care was to be exercised in determining the following points in addition to those already mentioned:

(*a*) The sex (bulls, oxen, cows, heifers, and calves under six weeks of age).

(*b*) The age (six weeks to one year; one to three years; three to six years; over six years).

(*c*) The race or breed.

(*d*) The source of the cattle, with statement whether the business is chiefly in pasturing or stabling them.

(*e*) The seat of the disease; external (udder), internal (only in slaughtered cattle), under the following heads:

Affection of only one organ with the related serous membrane and lymphatic glands.

Extension upon several or all organs of the body cavity.

Extension into several cavities of the body.

Existence of tubercles in meat.

Generalized tuberculosis.

(*f*) The quality of the meat from tuberculous animals (first, second, and third grade).

(*g*) The veterinary police regulations as to the disposition of the meat of tuberculous animals.

To these answers may be appended general information concerning the distribution of tuberculosis, heredity, contagion, etc.

In response to this circular the governments of the various States issued instructions to the various department officials, veterinarians, and meat inspectors, embodying in tabulated form the questions formulated in the circular. These were issued at different times during the year 1888, and the statistics were to cover one year from the time they were begun. The results of these inquiries will of course not be made known for some time. That they will, however, lead to stringent measures for the suppression of the disease and the greater protection of human health there can be little doubt.

* Veröffentl. d. kais. Gesundheitsamtes, 1887–1888, passim.

DIVISION OF GARDENS AND GROUNDS

SIR: I have the honor to submit the following report on matters pertaining to the operations of this division.

The number of plants sent out during the year aggregated a little over 45,000; these were mostly plants having more or less of economic value, in contradistinction from those cultivated for their ornamental qualities. The bulk of those distributed consisted of grapes, both foreign and native varieties, olives, strawberries, raspberries, Japan persimmons, figs, dates, camphor, tea, pineapples, mangoes, vanilla, oranges, lemons, guavas, etc.

The plants are distributed mainly by mail; they are carefully packed in damp moss, covered with oiled paper, then with strong wrapping paper securely fastened, and, if not detained in transit, reach any part of the United States in good condition.

GRAPES—MILDEW.

In some of the earlier reports of this Department much attention was given to grape mildew, its causes and prevention, with practical deductions based upon extended observations on the subject.

In the report for 1865, mildew is characterized as "the great obstacle in the way of extended grape culture," and a summary of some points is made as follows:

> The Peronospora, or mildew, which attacks the leaves on their under surface, is encouraged by the atmospherical conditions accompanying dull, cloudy weather, with occasional showers; or when heavy dews are deposited in positions where the rays of the sun can not penetrate, or at least where the moisture can not readily be evaporated. That, so far as is known, no peculiar constitution of soil or mode of soil culture has any influence in its prevention. That, so far as is known no mode of pruning or training, except so far as they agree with the next paragraph, has any effect in warding off the disease. That shelter and protection by covered trellises, or masses of foliage, will greatly modify if not entirely prevent injury from mildew.

The distinguishing peculiarity of a good grape climate is, primarily, that of an entire absence of mildew on the foliage. The presence of water or moisture on the leaves is necessary for the extension of mildew, therefore the best grape climates in this country are those of greatest immunity from dews.

A covered grape trellis was described in the Patent Office report for 1861. A trellis similar to that described was erected in the garden of this Department in the spring of 1863. The grape vines grown on this trellis were entirely free from mildew on the leaves and from rot in the fruit, and many varieties ripened under this protection that failed to mature on common trellises a few yards distant on account of the failure of the leaves during summer from mildew. The philosophy of the action of protection in this particular case seems to be its tendency to arrest radiation of heat, thus protecting the foliage from the cooling effects of night temperatures, which in turn pre-

vents condensation of atmospheric moisture on the leaves, thereby checking, to a certain extent, the predisposing cause of mildew.

In experimenting with registering thermometers it was found that, during clear, still nights of July, an exposed thermometer, projecting four feet from the covered trellis, would mark from 6 to 10 degrees lower than would a thermometer fastened to the trellis; the foliage being thus kept warmer and dryer on the protected plants, mildew was in reality prevented. It was also found that the fruit ripened on protected vines some time before that on vines not protected.

It would therefore appear that the best grape climates or localities would be those where dews were light or altogether absent. Such localities can be found. Indeed, it may be observed that wherever native grape culture has become popular and extensive, it is in localities where exemption from heavy or frequent dews prevail. These localities may be found either surrounded by large bodies of water or on hill-sides at certain elevations.

The influence of large bodies of water in ameliorating climates is well authenticated, and is often turned to practical advantage in fruit culture. Briefly stated, the water accumulates heat as warm weather prevails, which is radiated at night, and its influence is felt on vegetation in islands, which may occur as well for a considerable distance inland from the margin of the water. The presence of this stratum of air is evidenced by the absence of light frosts during late fall, and the freshness of vegetation as far as the heated atmosphere extends, while immediately beyond its influence a wintry aspect prevails.

In this case the cause of exemption from cold also prevents the formation of dew, and is so far favorable to the healthy growth and freedom from mildew of the grape.

Again, in districts where hills and valleys are closely and distinctly defined, there are, at certain elevations on the hill-sides, a zone or belt where dews are not known and where frosts are modified. The width of this belt varies according to the degree of cold and, to some extent, configuration of surface, but it exists in all countries that are traversed by high mountains and deep valleys. Several years ago, when collecting data on this subject, a correspondent in Macon County, N. C., wrote as follows:

> The frost line is not permanently fixed at any particular height on a mountain, but takes a higher or lower range according to the degree of frost that produces it; within the space of eleven years its maximum height has been 300, and its minimum height 125 feet, vertical. Another fact ascertained is, that there is no fixed dew line on our mountain sides, but that it gradually abates as you ascend, and at the height of 300 feet the dew is too light to produce either rot in the berry of the grapevine or mildew on its leaves. Hence we understand why the thermal zone is both warm and dry; I will not venture to say that the grape will never rot within the limits of that zone, but I can say that the Catawba grape is altogether unreliable when planted in our low valleys, but where the vines are growing on the slopes of the mountains they have not failed to ripen their fruit for more than thirty years, whether the season was wet or dry. It is a fact that all attempts to cultivate the grape in our low damp valleys have utterly failed, the plants invariably being destroyed by mildew on the leaves, while the few vines that grow upon the small farms lying high upon the mountain sides have ever matured their fruit in the greatest perfection.
>
> In view of these facts, I say confidently that any well-conducted effort at grape culture will succeed, whether it be upon the slopes of our Alleghanies or upon the mountain sides that skirt the valleys of more northern States, and all that is required to insure success is to ascertain where this warm belt is, and to plant the vine within its limits.

In the report of the Department for 1867 mention is made of the

great success in grape culture in the region near Hammondsport, Steuben County, N. Y. Here the Catawba and other late grapes mature and reach remarkable perfection, taking the latitude into consideration. These vineyards are mostly on hill-sides extending for several hundred feet above the valley and surface of Keuka Lake. The soil is a drift formation, and the surface is thickly covered with loose shale. The marked adaptability of this locality for grape culture may be attributed to its elevation and nature of the soil. The general elevation of the land prevents the deposition of heavy dews, and as it is supplemented by the heat absorbed during the day by the abounding stony surfaces mildew is unknown, and the growth proceeds unchecked until it is arrested by frost. There is a happy combination of favorable conditions; the soil is of a character that insures a healthy but not an over-luxuriant growth; the young shoots commence to mature at an early period during the summer, and when they cease to lengthen they are brown and hard up to their extreme points. Then the fruit is fully ripened and the quality is of the best, for thoroughly ripened grapes can not be gathered from immature growths.

I consider this matter of selecting good grape-growing localities as of the greatest importance at the present time. In all localities where mildew prevails successful grape culture can not be realized without constant vigilance in the application of correctives and preventives, and even these can not always be depended upon. Failures will occur under the best management where the environments are inimical to best success, and in no event can an imperfect climate compare with a perfect one. In view of the fact that perfect localities for grape culture can be selected under climatic conditions of the most favorable character for the protection of the best vines, the subject can not be too strongly urged for the consideration of cultivators of the grape.

WELL-RIPENED WOOD.

This is a technical phrase much used by fruit-growers to indicate a favorable condition in fruit-bearing plants, and as indicating the basis of success for fruit production and healthy vitality of the plant. No plant can long remain in a state of health if placed under conditions where its yearly growths do not mature, and it can not be too vividly impressed upon the mind of the cultivator of fruits that full and complete maturity of the seasonal growths of his trees and plants is the foundation of success. Without it, so far as fruit production is concerned, failure is inevitable.

The amount of cold which plants can endure without injury depends greatly upon the degree of maturity of their growths. Too much importance can not be placed upon the recognition of the fact that whatever tends to render plant tissue moist increases the susceptibility of the plant to injury from cold, and whatever tends to reduce humidity and hasten the conversion of fluid-matter into woody fiber increases its power of resisting cold, and it is clearly within the province of the cultivator to largely control this power of resistance in plants so far that failures or successes will in many cases depend upon his perception of the application of principles influencing vegetable growth.

It would be no easy task to determine how much of the disappointments and failures in fruit culture are due to luxuriant late

growths which have been struck by cold, and growth arrested before reaching maturity.

The amount of cold that plants can resist without being injured can not be definitely answered, because a plant will sometimes be destroyed by a degree of cold that it previously encountered without harm. This simply shows that the resisting powers of plants are not constant, but that they are dependent upon the condition of growth with reference to its maturity.

Future investigation will undoubtedly determine that most of the so-called diseases of plants originate from injuries received from sudden checks to growth, and it will likely be found that the results, although ultimately fatal, may linger for long periods before final termination, and observation has led to the conviction that such instances are by no means rare.

It may often be observed that in an orchard or plantation of trees of any kind individual plants will suffer and show disease while closely neighboring plants remain in perfect health. In such cases it will be found that the injured plants are those which, for some reason, are the most succulent of growths, and succumb to influences from which those of mature growths are exempt, and thus "the one is taken and the other left."

The result of cold acting upon succulent shoots is well exemplified in the case of peach trees. The disease known as "yellows" has long been attributed by reliable authorities, and this on grounds which have never been successfully controverted, to the freezing of immature shoots in the fall.

Downing, forty years ago, in his "Fruits of America," referring to peaches, says:

> And it is well worth remarking that certain fine old sorts, the ends of the branches of which have a peculiar mildewed appearance, which seems to check the growth without impairing the health, are rarely if ever attacked by the yellows. Slow growing and moderately productive sorts are almost entirely exempt.

Again, on the same subject, he states that—

> The most luxuriant and healthy growing varieties appear most liable to it. Slow growing sorts are rarely affected.

In Britain, peaches are always grafted on plum stocks, which has a somewhat similar effect upon the peach as that produced by grafting the pear on the quince; that is, the growth is checked, and succulent late summer shoots prevented.

The following extract from a late number of an English periodical shows how the yellows in peaches is produced in that climate:

> I never had to deal with peach trees on peach stocks, but the history of the peach stock is not favorable in some climates. The late Mr. Thompson, of the Chiswick gardens, relates how the trees on the peach stock at Chiswick "invariably became affected" and were done away with as useless. In America the peaches are on the peach stock, and the trees perish wholesale from the same disease that attacked them at Chiswick, viz, the yellows.
>
> If I could be sure of a blazing sun and long hot summers I would use the freest growing stock I could get, but I am told that peach stock makes gross roots which produce equally gross shoots that can not always be ripened here, even under glass, and not at all out-doors, and a foundation of ill-ripened wood is the beginning of all evils.

The following remarks are taken from a Maryland paper of date November, 1870:

> I am clearly of the opinion that the great drawback to the peach is that in many places it has no chance to fully ripen its wood; I mean that the trees grow so continuously, and sometimes very luxuriantly, until their foliage is suddenly destroyed

by frost. There is no gradual change of color in the foliage during autumn, followed by natural fall of leaves before cold weather, as we see in most other trees, but on the contrary, the trees maintain their green foliage and keep pushing out young leaves until a severe frost occurs and completely checks growth. This sudden check and its effects upon the vitality of the plant produce, in my opinion, the disease called yellows.

It is in the power of the cultivator, in some cases, to modify the conditions which encourage late growths, as well as to lessen the evil effects which result from frosted growths. It is readily apparent that trees set in constantly damp or very rich soil will have their growing season prolonged beyond those planted in dry or poor soils. It is also evident that in districts where the season for active growth is comparatively short, the soil should be well drained and manures sparingly applied, and only in spring. In such cases stimulating culture should not be prolonged through late summer, and even should weeds appear they should be mowed over with a scythe rather than to disturb the soil by cultivator or plow.

But something can be done even with plants that have been injured by the freezing of unripened growths, and that is the immediate removal of the injured shoots, pruning them back to sound wood. If this is performed in time the plant may escape further injury.

In some parts of Florida the orange trees occasionally suffer from slight frosts. During an unusually severe frost a few years ago many of the young orange groves suffered quite severely from freezing of succulent shoots. Hundreds of plants were destroyed and were removed during the following summer, and hundreds of others lingered on for a time, making sickly, yellow-leaved shoots, indicative of the cause of their unhealthiness. A prompt removal of the injured shoots would have saved most of these trees from utter destruction.

One of the most effectual methods of hastening the maturity of yearly shoots is that of pruning the roots, or by restricting their growths. The restriction of root-growth is applicable to plants in pots or tubs. Florists recognize the fact that, with many kinds of plants, the best flowering results are obtained when the pots in which they are growing become well filled with roots. When this condition is reached vigorous growth is checked and flower buds are produced in profusion. With some perennial plants this cramped condition of roots is allowed to exist for years, the plants being stimulated during the period of wood extension by applications of liquid manures.

Pruning the roots to hasten maturity of wood growth is of long and successful practice. In no instance have we seen it so marked as when applied to the roots of Asiatic conifers, and also those of our own Pacific coast. These plants have a tendency to make late growths during the moist autumn weather of the Eastern States, and this growth is mostly destroyed by early winter frosts. A marked instance is recorded where an avenue of the Japan cedar, *Cryptomeria Japonica*, had each alternate tree root-pruned in August, which completely stopped their growth for the season. The trees not operated upon added from 18 inches to 2 feet to their growth, after the root-pruned specimens had ceased to lengthen. The result was that the trees operated upon stood through the winter unharmed, while those not root-pruned were frozen back so severely that they never recovered, but gradually died of the yellows.

WATERING PLANTS IN POTS.

"How often should I water my plants?" This question is very frequently asked, and it is a rather perplexing one to answer definitely; a general answer would be: Never apply water to a plant until it requires it, that is until it is dry, and then supply a sufficient quantity to saturate the soil, which will be indicated by the surplus passing through the drainage.

Novices in plant culture usually make the mistake of merely sprinkling the surface of the soil, perhaps daily, without any time applying enough water to saturate the mass. Plants can not flourish under such conditions; the surface will appear wet, while the main body of the soil is hard and dry. One drawback to properly watering plants in parlor and window gardening (to which these remarks are more particularly directed) arises from the inconvenience attending the use of water in sufficient quantities; another evil is the dryness of the air. Both of these obstacles to success can be greatly modified by the use of a table properly fitted for the reception of the flower pots, or small vases in which the plants are kept. This table may be of any required size; a surface of 3 by 2 feet would be suitable for most windows; it should be made tight and neatly fitted. A ledge is made by fastening a strip 3 inches wide around the edge; then fill with two inches of clean, white sand, upon which the plants are placed; lining the table with zinc would completely guard against drip. The table should be fitted with rollers to facilitate the operation of watering and cleaning the plants. With a table of this kind the plants can be watered freely, and occasionally sprinkled, without any injury to surrounding objects. The sand should be kept constantly wet, so that moisture will be evaporated from it, and thus overcome, in some degree, one of the chief obstacles to the successful culture of plants in dwelling-rooms—a dry atmosphere.

There are a few general rules with regard to watering plants which may be noted. Watering should be preferably applied during the early part of the day, especially so in the winter season. Plants in pots well supplied with roots will require much more water than those which are newly potted or have a quantity of soil with few roots. Plants with narrow or small foliage will not use so much water as those with large spreading leaves. Plants in the shade will not need as much water as will those in the sun; a damp atmosphere will also reduce the necessity of water at the roots. Plants that are growing freely will require a regular supply, as they are sensitive of a check at this period; on the other hand, plants which are comparatively resting will need but little, and the supply gradually diminished as growth is being completed.

But in cases when water is applied it should be done copiously, and when gradually withheld the watering should be less frequent, not less in quantity, when it is necessary to make the application.

CITRON, CITRUS MEDICA.

The thick rind of the citron is valued for the purpose of candying or preserving in sugar for use in confectionery, etc. Growers of citrous fruits in California and Florida have repeatedly requested information as to the method of preparation and manufacture of

this condiment. As contributing to this information, the following extract from an authentic source is offered:

In all the countries I have mentioned above as contributing the raw fruit for this industry, it is treated in the same manner for the over-sea passage. The fruit is simply halved and placed in hogsheads or large casks filled with a fairly strong solution of brine, the fruit being halved merely to insure thorough perservation of the rind by an equal saturation of the interior as well as the exterior surface. In these casks it arrives at the doors of the manufactory.

The first process to which it is then subjected is the separation of the fruit from the rind. This is done by women, who, seated around a large vessel, take out the fruit, skillfully gouge out the inside with a few rapid motions of the forefinger and thumb, and throwing this aside place the rind unbroken in a vessel alongside them.

The rind is next carried to large casks filled with fresh cold water, in which it is immersed for between two and three days to rid it of the salt it has absorbed. When taken out of these casks the rinds are boiled with the double object of making them tender and of completely driving out any trace of salt that may be still left in them. For this purpose they are boiled in a large copper cauldron for a time varying from one to two hours, according to the quality of the fruit and the number of days it has been immersed in the brine. When removed from this cauldron the peel should be quite free from any flavor of salt, and at the same time be sufficiently soft to absorb the sugar readily from the sirup, in which it is now ready to be immersed.

The next process to which the rind is subjected is that of a slow low absorption of sugar, and this occupies no less than eight days. Needless to say that the absorption of sugar by fresh fruit in order to be thorough must be slow, and not only slow, but it must be gradual—that is to say, the fruit should at first be treated with a weak solution of sugar, which may then be gradually strengthened, for the power of absorption is one that grows by feeding. The fruit (and this holds good more especially with the rind) would absorb with difficulty and more slowly if plunged at once into thick sirup than if gradually treated with weak solution easier of absorption, and by which it has been thoroughly permeated first. It is a knowledge of this fact that governs the process I now describe.

The fruit has now passed into what I may call the saturating room, where on every side are to be seen long rows of immense earthenware vessels about four feet high and 2½ feet in diameter, in outline roughly resembling the famed Etruscan jar, but with a girth altogether out of proportion to their height, and with very short necks and large open mouths. All the vessels are filled to their brims with citron and orange peel in every stage of absorption, *i. e.*, steeped in sugar of (roughly speaking) eight different degrees of strength. I said before that this is a process that occupies almost always eight days, and as the sirup in each jar is changed every day, we may divide the mass of vessels before us into groups of eight. Take one group of this number, and we are able to follow the fruit completely through this stage of its treatment. With vessels of such great size and weight, holding at least half a ton of fruit and sirup, it is clearly easier to deal with the sirup than with the fruit. To take the fruit out of one solution and to place it into the next stronger, and so on, throughout the series, would be a toilsome process, and one, moreover, injurious to the fruit. In each of these jars, therefore, is fixed a wooden well, into which a simple suction-pump being introduced the sirup is pumped from each jar daily into the adjoining one.

"How is the relative strength of the sirup in each jar regulated?" is the next question. "The fruit itself does that," is the foreman's reply; and this becomes clear from the following explanations: Number your group of jars from 1 to 8 respectively, and assume No. 1 to be that which has just been filled with peel brought straight from the boiler, in which it has been deprived of the last trace of salt, and No. 8 to contain that which, having passed through every stage of absorption but the last, is now steeped in the freshly prepared and therefore strongest solution of sirup used in this stage. "We prepare daily a sirup of the strength of 30 degrees, measured by the 'provino,' a graduated test for measuring the density of the sirup," continued the foreman, "and that is poured upon the fruit in jar No. 8. To-morrow the sirup from this jar, weakened by the absorption from it by the fruit of a certain proportion of sugar, will be pumped into jar No. 7, and so on daily through the series. Thus, No. 1, containing the fruit itself, regulates the strength of the sirup, as I said." "But if the sirup has lost all its strength before the seventh day, or arrival at jar No. 1?" we ask. "Care must be taken to prevent that, by constant testing with the 'provino,'" is the reply; "and if that is found to be the case, a little stronger sirup must be added to the jar."

A slight fermentation takes place in most of the jars, but this, so far from being

harmful, is regarded as necessary, but of course it must not be allowed to go too far.

There is yet another stage, and that perhaps the most important, through which the peel has to pass before it can be pronounced sufficiently saturated with sugar. It is now boiled in a still stronger sirup, of a density of 40 degrees by the testing tube, and this is done in large copper vessels over a slow coke fire, care being taken to prevent the peel adhering to the side of the vessel by gentle stirring with a long paddle-shaped ladle. The second boiling will occupy about an hour.

Taken off the fire, the vessels are carried to a large wooden trough, over which is spread a coarse, open wire netting. The contents are poured over this, and the peel distributed over the surface of the netting, so that the sirup—now thickened to the consistency of treacle—may drain off the surface of the peel into the trough below. The peel has now taken up as much sugar as is necessary.

Now comes the final process, the true candying of the covering of the surface of the peel with the layer of sugar-crystals which is seen upon all candied fruits. To effect this a quantity of crystallized sugar—at Leghorn the same quality of sugar is used as is employed in the preparation of the sirup—is just dissolved in a little water, and in this the now dried peel, taken off the wire netting, is immersed. The same copper vessels are used, and the mixture is again boiled over a slow fire. A short boiling will suffice for this, the last process, for the little water will be quickly driven off, and the sugar upon cooling will form its natural crystals over the surface of the fruit. Poured off from these vessels, it is again dried upon the surface of the wire netting, as before described. The candying is now complete, and the candied peel is ready for the packing-room, to which it is carried off in shallow baskets.

In the packing-room may be seen hundreds of boxes of oval shape, or, if I may so speak, of rectangular shape, with rounded corners and of different sizes, for each country prefers its boxes to be of a particular weight, Hamburg taking the largest, of 15 and 30 kilograms; the United States of America preferring smaller, of 10 and 12 kilograms; whilst England takes the smallest, of 5 kilograms, and one containing about 7 English pounds. The wood of which the tops and bottoms of these boxes are made comes to us in thin planks from Trieste, and a skillful packing is generally done by women, and the boxes are lined with white paper. They are then packed in cases of 100 kilograms, ten of the smaller American boxes filling a case. The candied peel is now ready for export.

HORTICULTURE IN THE DEPARTMENT.

It having been suggested that a brief recital of some, at least, of the operations of this division since its establishment in the organization of the Department be made, and convinced that a desultory history of work done in this line would be instructive at this time, I have the honor to submit the following as indicative of the performance of duties pertaining to this office since it was placed in my charge, dating from September, 1862.

OBJECTS AND AIMS OF THE EXPERIMENTAL GARDEN.

At the request of the Commissioner of Agriculture, dated October 10, 1862, I prepared a detailed statement under the above heading, of which I note the following brief:

(1) To procure and encourage the transmission of seed, cuttings, bulbs, and plants from all sources, both foreign and domestic, for the purpose of testing their merits and adaptation in general, or for particular localities of this country.

(2) To procure, by hybridizing and special culture, products of a superior character to any now existing.

(3) To ascertain, by experiment, the influences of varied culture on products, and the modifications effected by the operations of pruning and other manipulations on trees and fruits.

(4) To investigate more thoroughly the various maladies and diseases of plants and the insects that destroy them.

(5) To provide ample means for thoroughly testing samples of all seeds and other contributions that may be received.

(6) To cultivate specimens of the various hedge plants and exhibit their availability for that purpose.

(7) To cultivate a collection of the best fruit trees and plants, such as grapes, apples, pears, peaches, strawberries, raspberries, etc., so as to compare their respective merits.

(8) To plant a collection of choice shrubs adapted for decorating gardens and landscape scenery.

(9) To erect glass structures for the twofold purpose of affording the necessary facilities for cultivating exotic fruits and plants, and to furnish examples of the best and most economical modes of constructing, heating, and managing such buildings.

Such was the groundwork of objects and aims then suggested, the development of which has been constantly kept in view.

GRAPES.

A very complete collection of native grapes was obtained and planted during the spring of 1863. This collection was increased from time to time as new varieties were introduced. As they fruited their merits or otherwise were noted and published in reports. Much attention was given to the cause and effect of mildew and other fungoid diseases. From information thus gained it was shown how to choose the best localities for grape culture, where diseases would be measurably avoided. It was shown also that by covering the grape trellis with a comparatively narrow wooden coping the vines were completely exempted from leaf mildew and largely protected from rot of the fruit. To prove that these diseases were of atmospheric origin, a rude glass structure was erected by placing a few glazed sashes against a common board fence. A collection of native grapes were planted in a line 4 feet from and parallel with this inclosure. In due time two leading stems were secured from each plant, one of which was trained under the glass roof, and the other to the outside trellis where the plants were set. This arrangement was continued for six years, with the same result each year, a fine crop of finely ripened fruit under the glass, and the usual failures from leaf mildew and rot on the outside branches. The fruit of the Iona under the roof was pronounced superior to some of the foreign kinds under glass, while the other half of the plant never ripened a bunch, and finally its badly ripened wood was completely destroyed.

The study of this extensive collection of native grapes enabled the superintendent to furnish a contribution towards the preparation of a classified list, showing the relation of each variety to the particular native species from which it had been produced, also those which had originated from hybridization with the foreign species. This was published in the annual report for 1869, and was accompanied by a description of the relative values of varieties for wine, or for table use, or for both; also the districts and climatic conditions most suitable for their successful cultivation. Previous to the publication of this list no particular attention had been given to the subject by grape-growers; it was, however, recognized as being valuable, and attracted attention to important facts connected with the culture of the grape.

In the spring of 1870 a collection numbering over ninety varieties of the foreign species, *vitis vinifera*, were planted in a glass structure specially erected for them. The object of this collection was mainly for purposes of propagation. From time to time the less valuable

have been removed and new varieties introduced. Plants from these vines have been distributed on the Pacific coast, also in western Texas, and more recently somewhat numerously in parts of Florida.

For several years, beginning in 1876, the vines in this grapery were severely injured by the insect known as the grape thrips; applications of tobacco water, quassia water, etc., on the foliage, as also fumigations of tobacco stems, had the effect of keeping these insects in check, but, having to be abandoned when the fruit was ripening, as it would thus be rendered unfit for use, the insects would then increase rapidly and destroy the foliage, so that the utter destruction of the plants seemed inevitable, unless some more effectual means could be adopted to annihilate the insects. This means was adopted. It consisted simply in covering the floor of the house with tobacco stems, the refuse of cigar manufactories; this was repeated for three seasons, when it was discontinued, no thrips having been seen since.

PEAR TREES.

In the fall of 1862 a collection of pear trees numbering one hundred and twenty plants was set out. These were in sixty varieties, one of each variety on quince roots, and one of each on pear roots; the purpose being mainly to ascertain what merit, so far as relates to early fruiting, the dwarf tree had, as compared with the standard. After the lapse of a number of years it was found that some varieties proved to bear as early on pear roots as their respective duplicates on the quince. Of these, the most precocious on the pear were the Howell, Buffum, Beurre Giffard, Bartlett, Beurre Clairgeau, Belle Lucrative, and Dearborn's seedling. The trees were all of the same age when planted, soil and locality alike, and all made a healthy and even luxuriant growth.

In 1870 a collection of pears, all on pear stocks, were set out on purpose to illustrate results of non-pruning. These, when planted, were pruned close, so that they appeared like walking-canes; no further pruning was permitted until, in after years, some limbs were entirely removed where branches became too thick and crowded. But no "shortening in," as it is termed, was performed on the points of branches; even when the yearly leading growths acquired a length of three feet or more they were not disturbed, and in the course of two years these shoots were covered with fruiting spurs, and ultimately with fruit from bottom to top. On the contrary the cutting back, or shortening in, of these young growths simply induces a thicket of young shoots instead of forming fruiting spurs; in fact such treatment destroys the buds from which the fruit-bearing short branch processes are formed.

PEACHES.

During the fall of 1863 a small orchard-house was planted with peach and nectarine trees, for the purpose of showing the arrangement and management of trees under glass protection. A bed of soil 9 inches in depth was laid over a drainage foundation of broken brick bats and oyster shells, and trees planted about 5 feet apart. Ample means for ventilation was provided, as the purpose was not to force the trees by heat for early fruit, but to illustrate the effects of a shallow bed of soil in preventing luxuriant growths and hastening and advancing precocity in bearing. Taking the size of trees and small space they occupied, the crops were excellent and of the

finest quality. When the fruits attained the size of marbles, a weekly drenching of guano water was applied to the soil; this enabled the trees to carry a large crop of large fruit.

To further show the controlling influence of restricting root-growth in the production of fruit, and for other purposes, several wooden troughs were constructed in which peach trees were planted and set in the open air. These were made of boards 10 inches wide for sides and bottom, filled with soil, the trees set about 3 feet apart in the troughs. The produce on these trees proved to be very satisfactory. A trough 7 feet in length contained three trees, and the whole could easily be carried by two men; the suggestion was made that, in northern latitudes, where peaches and nectarines do not thrive in ordinary orchard culture, or in city yards where space is limited, an arrangement of this kind would afford an agreeable recreation and some fruit to the owner.

In severe climates the whole affair could be kept in a cellar or a protected shed during winter.

JAPAN PERSIMMONS.

Persons familiar with the cultivated fruits of Japan unanimously agree in praise of the persimmon of that country. In order to introduce them here an order for seeds was placed in the office of the United States legation in Japan. Consequently, early in the summer of 1863 a package of these seeds was received and planted at once. This was the first effort, so far as known, to introduce this fruit into the United States for the purpose of testing its adaptability for general or special culture and use.

Several importations of seeds were made from time to time, from which plants were raised and distributed in different States. The reports from these, as well as tests made here, indicated the climatic conditions necessary for their successful culture. About ten years after the receipt of the first seeds, it was ascertained that a nursery had been established at Tokio, Japan, and that special attention was directed to grafting the best varieties of persimmons by name. Yearly importations of these were made, and the plants distributed in selected localities. In 1878 a large consignment was widely distributed in California by agents of the Department in that State. They are now growing largely in various of the Southern States. The Japan persimmon may be said to be about as hardy as magnolia grandiflora; some varieties are hardier than others, but all are perfectly safe where the thermometer does not fall below 12° above zero. The demand for plants is now well supplied by nurserymen, especially those in the South, so that their distribution by the Department has greatly fallen off. The names of imported varieties have given much confusion, as the same name would be found on different kinds, but this is gradually being corrected by those who grow the fruit, and by nurserymen who propagate the plants.

CINCHONAS.

The cinchonas, which furnish quinine, have been raised and distributed to some extent for many years. The value and demand for this drug were strong incentives to efforts looking towards its home production. Seeds of several species were received in 1864, and from these, several hundred plants were obtained, and were distributed

mainly in California and Florida. Since the first distribution many others have been made, but the reports that have been received do not indicate success at any point where they have been tried. In the cinchona plantations which have been formed in India, the best results are said to be obtained in a warm, equable, and very moist atmosphere, at elevations where the mean yearly temperature indicates 64°; and in those established in the Isle of St. Helena the plants did well at an elevation of 1,500 feet above the sea-level, in rich lands bathed in moisture, the mean temperature for the year being 60°.

If further experiments are made in the United States, they should be confined to the locality of San Diego, Cal. According to the reports of the Signal Office, the mean temperature for the year at San Diego is 60°, the highest monthly mean reaching 68° in August, and the lowest monthly mean being that of 53° in January and February. These figures correspond closely with those of St. Helena, so far as concerns thermometric readings; but the thermometer alone is not a safe guide in comparisons of this kind; the hygrometrical condition of the air being of even greater importance as regards vegetable growth. It has been reported that the cinchona plantations at St. Helena have been abandoned, but I have not seen any statement giving reasons for this action.

CHINESE TEA PLANT.

The tea-plant of China was first introduced in large quantities in 1858 by the Commissioner of Patents, who made distributions of them in the Southern States. But little attention was given to their culture at that time, except as a merely domestic product; the cost of labor and manipulations of manufacture precluded the idea of competition with low-priced Asiatic labor.

The successful progress of tea culture in India, where labor-saving machinery was employed in its manufacture, suggested the probability that it might be made profitable in some parts of this country, where labor-saving appliances are usually forthcoming as soon as their necessity is made known.

Following this idea, tea seeds were imported from Japan. Plants were in due time raised in quantities to warrant liberal distributions, and when, about 1867, it was found that an abundance of tea seed could be procured in some of the Southern States from plants that had been distributed from the importation of 1858, it materially enhanced facilities for increasing tea-plants in any desirable quantity.

The supply of tea plants has been constantly kept up, at first with faint but increasing hopes that the production of tea would become a profitable industry, mainly through the introduction of machinery for the drying, roasting, twisting, and other manipulations supposed to be necessary, but always with a view of introducing a domestic commodity of which any one could avail themselves in climates where the plant could live in the open air without protection,

As our knowledge of the tea industry widened it became evident that even more than the cost of the labor, the controlling factor of profitable production, was rain-fall. In British India tea plantations are not considered profitable where the rain-fall is less than 80 inches yearly. In some parts 120 inches yearly rain-fall is recorded, and the production there is at its maximum. In gathering, the young points of the growing shoots (having three or four small tender leaves) are pinched off between the thumb and finger; this checks the growth of the plant for a longer or shorter period, depending upon climate.

If warm and dry it will be some time before a second crop of shoots are produced; if warm and moist, only a few weeks will intervene between the pickings. With abundance of moisture the plants furnish from twelve to eighteen crops during the season. Thus pickings are continuous, and the manufacturing machinery is constantly employed. In dry climates only a very few pickings could be secured during the season. For long periods the machinery of manufacture would be idle, while the product would be inferior; the leaves would be hard and woody, as compared with the thin juicy leaves produced in warm climates saturated with moisture. Irrigation would be indispensable in any attempt to grow the article anywhere in the United States to commercial advantage, independent of considering the cost of manual labor here as compared with that of Asiatic countries.

For these reasons no effort is made to encourage investments in the culture of tea, but from five to ten thousand plants are distributed annually in districts where a zero cold rarely if ever pertains, and where the article can be prepared for domestic use by simple methods of drying and roasting the leaves. Hundreds of families avail themselves of this mode of securing a beverage, and samples have been received here of more than ordinary quality of teas prepared by methods available in most households.

COFFEE.

Many thousands of coffee plants have been raised from seed and distributed in Florida and California and in some parts of Texas, but its growth, as furnishing a product to enter into commerce, is rather problematical. In southern Florida, below 27½ degrees north latitude, coffee plants withstand the climate in ordinary seasons and occasionally produce ripe berries. Several years ago a quantity of ripe seed was received from Manatee, the produce of plants growing at that place. These seeds vegetated freely and produced good plants. Since that time we have learned that the original plants had been frozen to the ground but had sprouted up again as vigorous as ever. Authorities on coffee culture very generally coincide in the opinion that it can not be grown profitably in any climate where the temperature falls as low as 50° Fahrenheit at any time of the year. This refers to the production of the fruit. Many plants will grow in climates too cold for perfecting their fruit with any degree of regularity, if at all, and this is the case with the coffee plant; a lowering of temperature occurs before the fruit is ripe, and its progress toward maturity is retarded if it is not completely checked, and these climatic conditions may occur in any part of Florida.

About fifteen years ago a new species of coffee was introduced from Liberia. The plant was described as being of more robust growth with larger berries than the Arabian. Hoping that it might also prove to be more hardy, after several failures to procure fresh seed from Liberia (coffee seeds of all kinds soon lose their vitality), a few were ultimately secured, from which plants were raised, but it was soon made evident that the Liberian species was more tender than the Arabian.

ORANGES, LEMONS, AND OTHER CITRUS FRUITS.

In 1863 a collection of named oranges was begun by the purchase of three varieties, a Maltese oval, a St. Michael, and a Mandarin. Previous to that an importation of plants from Japan included plants

of the Kum-quat, both of the oval-fruited and the round-fruited varieties. This is the *Citrus Japonica* of botanists. Its fruits are about the size of a large gooseberry and are held in high esteem for preserving in sugar. After securing suitable stocks, the *Citrus triptera* being the only stock upon which the Kum-quat will succeed, a large number of plants were grafted and after a time distributed in orange-growing localities. This species is much hardier than the common sweet orange, and the stock *C. triptera* will stand a zero cold.

In 1871 an extensive collection of the citrus family was obtained from Europe. Of these several were found worthy of propagation. This importation was badly infested with a scale insect which greatly retarded the growth of the plants and prevented their propagation, and consequently their distribution, until the insect could be destroyed. This was ultimately effected by the persistent use of coal oil applied in water. One gill of oil was thrown into 5 gallons of water, agitated with a syringe, and sprayed over the trees. This destroyed the insects without injury to the plants. The method of making an oil emulsion before mixing with water is a vast improvement upon the primitive system described above.

During 1868 I learned through a correspondent then in Bahia, that the oranges there were of a superior character to any seen in the United States. An order was sent for a small shipment of plants, which, after considerable delay and minute advice as to budding, packing, and shipping, were received here in fairly good condition. In due time buds from these were inserted in orange stocks, and the young plants so produced were distributed in Florida and California. They were sent out under the name Bahia, which name, without action by the Department, has been changed—first, to Riverside Navel, and subsequently to Washington Navel. As it is well known, this orange is conceded to be the best flavored and otherwise the best table fruit of its kind. It is brisk flavored, solid, seedless, and of large size.

A drawback to its general culture in some parts, especially in Florida, is its lack of fruit. The trees may flower abundantly and no fruit follow. As the flowers of this variety are nearly always destitute of pollen I have hitherto attributed its unfruitfulness to this cause, but I now feel convinced that the absence of pollen is its normal condition. This might have been surmised from the absence of seeds in the fruits, and when an occasional seed is found in them it is evidently the result of transported pollen. Physiologists state that the genus *Citrus* is very subject to a monstrous separation of the carpels, producing what are called horned oranges, or to a multiplication of the normal number of carpels, in which case orange is formed within orange, such fruits being called navel oranges.

This is its status at present in Florida. It is too uncertain in its fruitage to warrant extensive planting. On the contrary, its culture is extending in California far beyond that of any other variety.

The first importation from Europe included a variety labeled Braziliense. This proved to be undistinguishable from the Bahia, and as buds of the entire collection were taken to Florida shortly after reaching here it is surmised that this variety has given origin to the orange known in that State as Parson's Navel.

In the year 1878, a glass structure was erected for the special purpose of growing citrus trees. All new introductions are planted in this house and fruited before determining their value for propagation.

APPLES.

In the year 1871, the Department received from Russia a collection of apple trees. The efforts to secure these trees were commenced several years previous, but some time elapsed before they could be secured from any source which seemed reliable. Something over two hundred varieties were ultimately secured through Dr. Regel, of the Imperial Botanic Garden, St. Petersburgh; they were mostly in duplicate, and were planted on the grounds of the Department. When the first year's growth was completed all the young wood was cut off and the scions distributed to nurserymen and others who could utilize them.

The principal object of this importation was the hope that a greater variety of hardy apples might be secured for the rigorous regions in the Northern States, and especially with a view of extending the season by late varieties. The few hardy Russian apples which were then in cultivation in this country were early ripening kinds.

For the ten years following their introduction the crop of scions was distributed, and as the trees increased in size the distributions became heavy. The greatest number sent out in one year was 95,000 eight-inch lengths.

The trees were then removed. It was considered that the purpose of their introduction had been accomplished so far as the Department could be of any service, and the space they occupied was needed for other uses.

From this importation a few desirable apples have been added to the list of those worthy of cultivation; but it has possibly been of greater value in directing attention to northern Europe as a region where hardy fruits of various kinds may be found, and which may prove to be the means of introducing fruit culture in the more rigorous sections of this country, where fruit culture is but little known.

APPLES IN SOUTHERN STATES.

Twenty years ago the opinion was prevalent that the climates south of Maryland were not suited to the apple; at all events it was stated that winter, or long-keeping apples, could not be produced in the Southern States.

This statement was true as far as it referred to the winter apples of the Northern States, such as the Baldwin, Rhode Island Greening, etc. These varieties, when planted in Southern States, ripened during the fall and could not be kept as winter fruits.

Some of the most prominent nurserymen and fruit-growers in Virginia, North Carolina, Georgia, and other States, had long become aware of the futility of planting northern winter-keeping apples in their sections, and had been for some time industriously engaged in collecting winter varieties from among the many seedlings picked up in old fields and fence rows in these States, many of them having great local reputation for their excellence and good keeping qualities.

For the purpose of greater acquaintance with the apples of North Carolina (a State where this fruit attains its greatest perfection), a visit was made in the fall of 1869, which enabled me to collect samples of many varieties of repute in that and adjoining States.

An article descriptive of this collection, with sectional drawings and wood-cuts from photographs, appeared in the report of the

Department for 1869. About forty varieties were described, thirty of which proved to be of Southern origin, most of them unknown to Northern orchardists, and had never been noticed in pomological works.

The publication of this list not only effected its main object, which was to draw the attention of Southern planters to the fruits of their regions, but it had the effect to attract the attention of some Northern nurserymen, who procured collections from the South which, after testing, added several excellent fruits to those cultivated in the North.

OLIVES.

The introduction of the olive tree into this country dates back one hundred and fifty years; first, it is stated, in California by the Jesuits, and shortly afterwards in Florida, brought by a colony of Greeks and Minorcans. Since then up to the present time various attempts have been made to revive and extend its culture in the Southern States, which have in turn been abandoned. On the Pacific coast the revival of olive culture, instituted some years ago, seems to be now on a paying basis and is yearly extending.

The Department during the past twenty or more years has, at intervals, imported olive trees of noted varieties from which large numbers of plants have been propagated and distributed, mainly in the States south of this District. It is not a tender plant; it will usually withstand twenty degrees of frost, and even more in favorable localities.

Olive seeds are frequently called for, but this is an injudicious mode of propagation so far as securing plants of valuable commercial qualities.

The number of distinguished varieties of the olive in Europe is as great as the different varieties of our native grapes. It is therefore evident that plants raised from seeds, even if the seeds have been collected from the most esteemed kinds, may not inherit the qualities of the parent plant, and a plantation formed of such seedling plants may produce fruits of inferior value, causing disappointment and loss.

EUCALYPTUS.

In the year 1865 I saw a notice of some experiments conducted in German hospitals wherein it was made apparent that the Blue-gum tree of Australia, *Eucalyptus globulus* possessed anti-periodic properties. Acting upon this information, a package of seeds of this tree was procured through an Australian correspondent, which were sown during the spring of 1866. After three years, at which time the plants had reached a height of 20 to 25 feet, a number of them were cut down and submitted to chemical tests for alkaloids similar to the cinchona, but they failed to detect any indications of alkaloids of this character, and subsequent experiments afford additional proof that no part of the plant contained them. Nevertheless the febrifugal nature of the leaves appears to be well established, and preparations from them constitute a popular remedy in Australia and in other countries against fevers, and several preparations from various parts of the plant have the reputation of being successfully used in intermittent fevers. The leaves by distillation yield an essential oil which has been found to possess the properties of cajuput oil; it is known

in commerce as Eucalyptus oil or Eucalyptol; other species of Eucalyptus furnish oils which are sold under this name.

The Blue-gum tree yields an astringent substance which is applicable like catechu and kino in medicine. The leaves have a strong camphorated scent, and have been used in the cure of gunshot and other wounds. Their balsamic nature not only cures, but after a few hours' application all unpleasant odor is entirely removed.

But the great popularity for a time of the *Eucalyptus globulus* was owing to its reputed properties for preventing malarial fevers. Unhealthy districts in Spain, Italy, and in some parts of France, were planted with the Blue-gum, now called the anti-fever tree. Its antimalaria reputation soon reached the United States, and the demand for young trees became so great that the Department procured supplies of seed and propagated and distributed many thousands of the plants during several years from 1870. Their hardiness had been well tested here; it was found that they were destroyed when the thermometer went down to 24 degrees. As reports came in its climatic range could be more accurately located, which proved to be more limited than was hoped for at the start. It was destroyed by cold at Galveston, Tex., and in Florida as far as latitude 29 degrees. In California it is successfully grown, and is largely planted in certain parts of the State.

With regard to the sanitary value of the tree, it has been strongly stated that its value was owing to its rapid growth and great absorbent power of its roots in drying up wet and marsh lands, but it is no longer doubted that *E. globulus*, along with other species of Eucalyptus, evaporate with water a volatile oil and a volatile acid, which permeate the atmosphere and contribute to its invigorating and healthy nature and character.

The distribution of Eucalyptus plants has not been confined to this species. More than forty species have been propagated and sent out, but no special merit, either in hardiness or in utilizable economic products, has been noted from any of the species, so that their furthur propagation is abandoned, at least for the present.

FIGS.

The introduction of varieties of figs, and their propagation and distribution, was a matter of early as it has been one of constant consideration. Ever since the establishment of the Department it has been importuned to procure the true Smyrna fig, and although collections have been procured from various European sources—embracing all the popular figs of commerce—only in one importation were found plants named White Smyrna, and on fruiting it proved to be the same as the White Marseilles. Smyrna figs are probably multiple, as are Malaga grapes, and derive their names from places of export. It is well known that numerous varieties of figs are dried, and enter into commerce under the name of Smyrna figs.

The fig can be grown over a large part of the United States, and will withstand 20 degrees of frost when the young growths are thoroughly matured; this, however, seldom occurs north of Georgia, unless in some favored spots. Even in Georgia early winter frosts will kill the unripened wood.

In more northern localities the plants can be protected during the winter by bending the branches close to the ground, and covering them with a foot of soil.

If the young shoots have ripened properly this covering will pro-

tect them safely during the winter; if the wood is immature, covering will be of but little avail.

The ripening of the wood can be assisted by planting in a gravelly or sandy soil; if the soil is rich, growths will be made at the expense of the fruit.

Fig nomenclature is very puzzling, as the following list, with synonyms, will show. As usual with fruits, the best varieties have the greatest number of synonyms:

Angelique, syn., *Coucouelle, Madeline, Melitte.*

Aubique, syn., *Aubique Violette, Violette grosse.*

Bordeaux, syn., *Aubiquon, Figue-Poire, Gros-Rouge de Bordeaux, Petite Aubique, Violette, Violette de Bordeaux, Violette Longue.*

Black Bourjassotte, syn., *Bourjassotte Noir, Barnissotte, De Bellegarde.*

White Bourjassotte, syn., *Bourjassotte Blanche.*

Bourjassotte Gris, syn., *Early Yellow, Jaune Hative.*

Brunswick, syn., *Bayswater, Beyronne, Black Naples, Brown Hamburgh, Clementine, Hanover, Large Turkey, Madonna, Peronne, Red, Rose, Rose Beyronne, Rose Blanche.*

Early White, syn., *Blanche Ronde, Small White, De Deux Saisons, Early Small White.*

Black Genoa, syn., *Negro d'Espagne, Nigra, Noire de Languedoc.*

White Genoa, syn., *Large White Genoa, Large White.*

Black Ischia, syn., *Blue Ischia, Early Purple, Early Forcing, Nero Ronde Noire.*

Brown Ischia, syn., *Chestnut-colored Ischia.*

White Ischia, syn., *Brockett Hall, Nerii, Singleton, Green Ischia.*

Yellow Ischia, syn., *Cyprus, Yellow.*

Matta, syn., *Small Brown.*

Black Marseilles, syn., *Black Provence.*

White Marseilles, syn., *Adam's Fig, Raby Castle, Blanche, D'Athenes, Ford's Seedling, Pocock's, Marseillaise, White Naples, White Standard.*

Peau Dure, syn., *Peldure, Verte Brune.*

Brown Turkey, syn., *Blue, Blue Burgundy, Brown Italian, Brown Naples, Common Blue, Early, Fleur Rouge, Howich, Italian, Jerusalem, Large Blue, Lee's Perpetual, Murray, Long Naples, Purple, Walton.*

TESTING THE MERITS OF SPECIES AND VARIETIES OF PLANTS.

This was a subject of early consideration in the operations of the Department. In my report to the Commissioner for 1863, I alluded to the necessity for a series of experiments to test the comparative merits of cereals, vegetables, and fruits, most of which have run into a vast number of varieties, many of them being comparatively worthless. I quote as follows from that report:

> In a sale catalogue of agricultural and garden seeds now before me, there are enumerated 52 varieties of peas, 32 varieties of beans, 34 varieties of lettuce, 18 varieties of onions, 48 varieties of turnips, 42 varieties of cabbages, and 10 varieties of celery. No one desires, neither is it necessary, to cultivate all of these; it is therefore of much importance to know which are best and most suitable for the purpose required, whether early or late, large or small; whether productive, of good keeping qualities, or otherwise. Possessed of such information the buyer could make his purchases understandingly, and the seller would speedily drop unsalable sorts from his list and both would be gainers. As a commencement towards carrying out the above suggestions, 40 varieties of potatoes were procured, also many varieties of peas, turnips, and other plants, but owing to the limited space only a small quantity of each could be planted, not sufficient basis upon which to found any opinion. For purposes of comparative experiment in field and general garden crops, and for other necessary uses, the six acres of garden ground is altogether inadequate.

In 1864 Government Reservation No. 2 was placed under the control of the Commissioner of Agriculture for the purpose of an experimental farm. For several years test experiments were attempted with cereals, forage plants, and garden fruits and vegetables. In

1865 there was produced on the reservation 120 varieties of wheat, 16 varieties of rye, 17 varieties of oats, 70 varieties of peas, 30 kinds and varieties of beans, 18 varieties of cabbage, 14 varieties of lettuce, 13 varieties of onions, 43 varieties of potatoes, and 30 kinds of melons, and, in addition, many other forage plants, such as clovers and grasses.

In 1866 32 kinds of sorghum were cultivated, and many kinds of turnips, beets, etc. It soon became evident that as a farm the area was altogether too limited for the requirements of satisfactory results in this line; and when, in 1867, the Department building having been located upon the grounds, it became necessary to arrange them in a manner more in keeping with surrounding improvements.

In the spring of 1867 upwards of 50 species of grasses were sown, and their growth and main characteristics were noted weekly during the season. A plot 10 feet square was allotted to each, and the results were recorded in the report of the Department for that year.

Collections of small fruits, such as strawberries, raspberries, etc., have been maintained to some extent since the establishment of the garden; but with the present limited area in cultivation, extensive collections can not be accommodated.

LAYING OUT THE GROUNDS AND PLANTING THE ARBORETUM.

Having prepared plans for the arrangement of the grounds, comprising about 32 acres in all, and after underdraining and thoroughly plowing and subsoiling the whole area, a portion was ready for planting in the fall of 1869. The operations of 1868 were mostly confined to grading and road-making in close proximity to the Department building, which was newly occupied. A portion of the main road in front of the structure was finished with a concrete surface, the larger portion of the roadways being macadamized in the best manner.

Immediately in front of the building a geometrical arrangement of flower beds was introduced, finished and supported by a stone terrace-wall, surmounted with an ornamental iron balustrade, ending with two pavilions.

The plan for laying out the ornamental part of the grounds provided for an arboretum, in which would be represented, so far as space would admit, a specimen of every tree and shrub capable of existing in the climate, to be planted in strict accordance with a botanical system, and at the same time produce a high degree of effective landscape gardening and pleasure ground scenery—a combination not hitherto attempted on a similarly extended scale. The planting was virtually finished in 1871. The progress of growth has been satisfactory, and the landscape design is now fully developed.

The principles recognized in arranging the grounds, and their practical application, are briefly defined in an article prepared for and published in the Annual Report for 1869, under the title, Landscape Gardening.

THE CONSERVATORY.

In 1868 I submitted designs for a conservatory 320 feet in length and of an average width of 28 feet. The structure was completed and occupied in 1871.

The conservatory was erected for the purpose of maintaining a collection of economic or useful plants. No plants were to be ad-

mitted because of the beauty of their foliage or the beauty of their flowers, or for their historic interest; but only those which yielded, or furnished in some measure, commodities of commercial importance, of more or less value; also with a view to the propagation and distribution of such as might be deemed worthy of trial in suitable climates in this country.

This collection was so far advanced in 1872 that during the latter part of the year I prepared a descriptive catalogue of these exotic plants, in which about five hundred species were briefly noted and their uses explained.

This structure is heated by hot water circulating in iron pipes. In arranging the pipes a notable exception was made to the methods usually employed. The prevailing method was to incline the pipes for some distance from the boiler or water heater. In other words, the flow pipes were laid on an ascending grade and the return pipes on a descending grade. No uniformity existed as to either the height or distance of the ascending pipes; these conditions were regulated by the length of the building; if 200 feet in length, the ascent would be to that extent; if 20 feet in length, so would be the length of the ascending pipes; from these distances the water is conducted in a descending grade to the boiler. Observations having convinced me that the ascending pipe retarded the circulation of water, and that, other things being equal, the most rapid circulation is secured when the top of the boiler is the highest point in the whole arrangement, and all the pipes descending from that point until they reach the bottom of the boiler, I had the piping laid so as to secure as much as possible of a descending grade. For instance, in a length of 160 feet from the boiler to the end of the house, an upright pipe 3 feet in length is attached to the boiler, from which the pipe descends the whole length and returns back on a similar grade, making a uniform descent through 320 feet of pipe.

If the water absorbed and transmitted heat by conduction only, then the position of the pipes would be of but little importance; but as it is by convection, circulation or actual movement of the water, then gravitation and diminished friction are notably influential in the efficient working of the apparatus.

PINEAPPLES.

The climates in the United States suited to the pineapple plant are limited to southern Florida and perhaps some parts in southern California. This industry is rapidly becoming important in southeastern Florida, where the climate seems favorable to the profitable production of this fruit. With a view to assist in the extension of its culture the Department erected a glass structure for the propagation of the pineapple. An importation of the best selected varieties was made, and from these a few hundred plants have been raised and distributed among growers. Under a limited glass surface propagation proceeds slowly; a few plants of a kind, however, can soon be increased when planted in a suitable climate.

BUILDING GLASS-HOUSES.

All the glass-houses are constructed upon the fixed-roof plan, consisting of skeleton frame-work supporting a series of light sash bars for holding the glass. This method is not only cheaper than the

plan of heavy rafters supporting framed sashes, but by using less wood-work there is less shade and more light to the plants. Since the introduction of this method of building by the writer in 1850, together with the mode of glazing adopted, no other kind of roofing is used. The ordinary way of glazing window-sashes is to set in the glass, fasten it with triangular bits of tin, then fill the outer surface of the sash-bar with putty.

When this method is applied to green-house roofs it is almost impossible to prevent leakage. The frosts of winter and the hot suns of summer cause the putty to crack and fall apart, requiring continual repairs in the effort to maintain a water-tight roof, and only partially successful at best.

To make a permanently tight roof, the glass should be bedded in well worked, rather soft putty. A layer of this having been uniformly spread on the sash bar, the pane of glass is gently pressed on it until it reaches an equal bearing, and so working up a portion of the putty that it will fill all spaces between the edge of the glass and the wood work. After the surplus putty is neatly trimmed off, both inside and out, it is allowed to dry and shrink, then a coat of paint is applied which will fill up all crevices, and make a perfectly water-tight finish; if any slight leak should appear, a coat of paint will stop it.

After testing glasses of different sizes, panes 10 inches by 12 inches are preferred. For this sized glass the sash bars are placed 12½ inches apart, measuring from their centers, allowing one-fourth inch rebate on each side for the glass to rest upon; the pane is secured by brad-nails three-fourths of an inch in length, four to each pane, fastened at the corners; the two upper nails form a support to the next pane above, and their position determines the amount of lap, which should not be more than one-sixteenth of an inch; wide laps hold dust, which in turn holds water, which may freeze in frosty weather and split the glass.

Ventilation is provided for by hinged or by small sliding sashes on the roof, which can be fixed so as to prevent leakage.

HEDGES.

In the spring of 1864 specimen hedges were established with a view to showing the relative merits of various plants for this purpose, either as fences for farm or garden protection, or for forming neat boundary and dividing lines in pleasure grounds and lawns, or for shelter from cold and biting breezes. These specimens afforded much of interest to those seeking information in that line; an inspection of them afforded more information than could be conveyed by the most labored description. The following plants were used: Osage orange, *Maclura aurantica;* Honey locust, *Gleditschia tricanthos;* Buckthorn, *Rhamnus catharticus;* Berberry, *Berberis vulgaris;* Japan Quince, *Cydonia Japonica;* Beech, *Fagus sylvatica;* European Hornbeam, *Carpinus Betulus;* European Field Maple, *Acer campestre;* Japan privet, *Ligustrum Japonicum;* Hemlock Spruce, *Abies Canadensis;* Norway Spruce, *Abies excelsa;* Chinese Arborvitæ, *Biota orientalis;* American Arborvitæ, *Thuja occidentalis;* Evergreen Euonymus, *Euonymus Japonicus;* Silver Thorn, *Eleagnus parvifolius;* Jujube, *Zizyphus vulgaris.*

MISCELLANEOUS PLANTS PROPAGATED AND DISTRIBUTED.

Ramie, or China grass, *Boehmeria nivea:* Seeds of this fiber plant were procured early in the year 1865 and sown in a glazed frame. This precaution was taken because the seeds are very minute and have to be sown on the surface of the soil and pressed in without covering. Thousands of plants were produced and distributed throughout the country the following year. The distribution of the plant was abandoned when it became apparent that machinery was wanting to prepare the fiber for market, consequently there was no demand for it. The plant is easily cultivated, and could be produced in quantities should a demand arise. It is quite hardy south of this District.

New Zealand Flax, *Phormium tenax:* The fiber in the leaves of this plant is reputed for its strength. On the supposition that it might be utilized, seeds were procured from its native country, from which several thousands of plants were produced and distributed. The fiber is difficult of extraction and has been the subject of much experiment by chemists and others. The latest results prove that the fiber is held together by various kinds of gum, and when these are removed the fibers are quite short, and have no felting properties.

Sisal Hemp, *Agave sisalana:* This plant was introduced into Florida fifty years ago, but its culture was abandoned during the Indian war in that State. Some years ago a consignment of young plants of this, or an equally utilizable species, was received from San Domingo and they were distributed. At the same time plants of the next mentioned were received and sent to the same localities.

Cabuya fiber, *Fourcroya Cubense:* The leaves of this plant yield a useful fiber, somewhat similar to the last mentioned. Neither of the plants are yet cultivated to any extent in the United States.

Gum-arabic, *Acacia Arabica:* This gum is also found in other species of Acacia. Plants of these have been raised from time to time and sent out to southern climates. Quite a number of plants of *A. Arabica* have lately been distributed.

Cherimoyer, *Anona Cherimolia:* This, with other species of *Anona* which produce fruits in the West Indies and other warm climates under the names of sour-sop, sweet-sop, custard-apples, etc., were introduced here and distributed, mostly in Florida and California, some twenty-five years ago.

Camphor tree of Japan, *Camphora officinarum:* The Camphor tree has been distributed yearly, more or less, since the establishment of the Department. Many trees from the earlier distributions have now attained to considerable size and beauty. It is an evergreen, grows rapidly, and stands the coast climate at least as far north as the Carolinas. Of late years the distribution of this tree has averaged three thousand plants annually. They are sent mostly to Florida and Texas, where they answer a good purpose as ornamental shade trees, with a probability that when they become more plentiful and better known efforts may be made to extract camphor from the branches.

This product is obtained by chopping the twigs and branches into small pieces and boiling them with water in an iron vessel, stirring them until the camphor begins to adhere to the stirring utensil. It is then refined by sublimation, an operation requiring care and experience.

Cocoa-nut palm, *Cocoa nucifera:* About twenty years ago a consignment of cocoa-nuts was received from Central America, and some years later a small quantity was procured from the West Indies. These were distributed in localities where it was supposed that the plants would flourish. At that time but little was thought about the profitable culture of the plant, and it is presumed that no attention was given to the few sent out by the Department. Of late years, however, more attention has been given to this fruit in Southern Florida.

The Coca plant, *Erythoxylon Coca:* This plant has been under propagation for many years, but, like the cinchona, it has not found a suitable climate, so far, in this country. During the past few years considerable interest has been attached to the plant, and it has been in much request. Plants have been furnished to all applicants, and many of them have been sent to the Southern States and to California, but so far no one has reported success in its growth.

The Mango, *Mangifera indica:* The Mango, in some of its many varieties, is esteemed as one of the most delicious of tropical fruits. It is largely cultivated in the East Indies, where much attention is given to the propagation of the best selected kinds. Seeds of Mangoes have been procured at times during many years past, both from the East and West Indies, said to have been selected from the finest varieties, but no guaranty can be given as to the value of the fruit which they may produce. About ten years ago a case of grafted plants of esteemed varieties was procured from a botanic garden in Jamaica, West Indies, but owing to great delay in transportation few of the plants were found to be alive.

The Date palm, *Phœnix dactylifera:* Like the Mango, there are many varieties of this species, some of them quite superior in the quality of their fruits. Unlike most palms, the Date palm throws out suckers from its main stem, near the roots, so that it can be increased or propagated in that manner, and is often done with choice varieties. For many years the Department has distributed quantities of this palm which have been raised from imported seeds. Some of these importations consisted of seeds collected in southern Europe, where the hardiest varieties are cultivated.

Various efforts have also been made to secure suckers or offsets from kinds of reputed merit, but without success. Two importations have been received, and in both instances the plants proved to be dead. The cost and risk were so great that further efforts were abandoned.

Ginger, *Zingiber officinate:* Rhizomes of this plant have been distributed for a long time, but no reports of success have been received. Although a tropical plant, its annual growth is completed in a few months, like cotton, and it is probable that it could be grown wherever cotton will mature. The roots being lifted and kept warm and dry during winter will be in condition to plant the following spring. The treatment would be about the same as that given to a crop of potatoes. The conserve known as "preserved ginger" is an article of considerable commerce. It is prepared from immature roots, so that they are soft and succulent, and can readily absorb the sirup in which they are preserved.

The following-named plants have been propagated and sent out, most of them in quantities not exceeding a few hundred each:

Tamarind tree, *Tamarindus indica;* vanilla, *Vanilla planifolia;* cork oak, *Quercus suber;* black pepper, *Piper nigrum;* licorice, *Glycyrrhiza glabra;* basket willow, *Salix viminalis;* Japan varnish

tree, *Rhus vernicifera;* Pistacia nut tree, *Pistacia vera;* allspice, *Eugenia pimento;* the Lee-chee, *Nephelium Litchi;* gum-arabic plant, *Acacia Arabica;* the Carob tree, *Ceratonia siliqua;* cinnamon, *Cinnamomum zeylanicum;* mammea apple, *Mammea americana;* dwarf banana, *Musa Cavendishii;* Avocada pear, *Persea gratissima;* Japan medlar, or Chinese Lo-quat, *Photinia Japonica;* pomegranate, *Punica granatum;* Mexican pepper tree, *Schinus molle;* Cattleya guava, *Psidium Cattleyanum.*

Among the many papers prepared by me for the reports of the Department, the following are selected for reference, as bearing more practically upon topics illustrative of the work of this division:

Year.	Subject.	Page of Report.
1862	Shelter and Protection of Orchards	147
	On the Objects and Aims of the Garden of the Department	540
1863	On Pruning	552
	Spring and Fall Planting of Trees	557
	Mechanical Preparation of the Soil	24
1866	Remarks on Pruning and Training the Grapevine, with quotations and illustrations from various authors	97
1867	Notes on Grape Climates	27
1868	List of Species and Varieties of hardy Plants for the Arboretum	122
	Hints in Horticulture	194
	On Grape Culture	207
1869	Classification of Native Grapes	81
	Grasses and Forage Plants	87
	On Landscape Gardening	157
	Apples for Southern States	184
	Remarks on Pear Culture	198
1870	Plan of Department Grounds with references to position of Families of Plants	16
	Minor Vegetable Products and their Sources	170
1871	Minor Vegetable Products	105
1876	On Water Plants	62
	On Phylloxera Vastatrix	70
1877	On Acclimatization	49
	On Eucalyptus	51
	On Oranges	56
1878	Rotation in Cropping	200
	Sowing Seeds and Raising Young Plants of Forest Trees	203
1881	Notes on Semi-tropical and Other Plants	216
1883	On Grapes	182
1885	Mildews and Blights, Grape, Peach, Pear, and Potato	35
1886	Notes on Orange Culture	687
1887	Official Correspondence, answers to interrogatories on various subjects	673

Respectfully submitted.

WILLIAM SAUNDERS,
Horticulturist, Landscape Gardener, and Superintendent of Gardens and Grounds.

HON. J. M. RUSK,
Secretary of Agriculture.

REPORT OF THE CHEMIST.

WASHINGTON, D. C., *January* 1, 1890.

SIR: I submit herewith the following abstract of the work done in the Chemical Division of the Department of Agriculture during the past year.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

The work of the Chemical Division during the past year has been of a varied character. There has been the usual amount of miscellaneous work, but a gratifying decrease in the quantity of assays for the precious metals which have been required of the chemists of the division. The attempt to break a long established custom, even if it be plainly *extra legem,* is very difficult, and there are still many demands made upon the chemists of the Department of Agriculture by members of Congress and other influential people for the assay of gold and silver ores, and examinations of mineral waters, and for other work having no relation to agricultural investigations, and for the exclusive benefit of the parties interested. It is hoped that gradually all such work may be refused and remanded to chemists who shall be employed especially for that purpose by the parties interested.

There is another class of analyses which has also made a less demand upon the time of the chemists of the division. I refer to the analyses of soils and fertilizers from different parts of the country. In all cases during the past year, save in a few exceptional ones, the persons asking for such analyses have been respectfully referred to the agricultural experiment stations of the States of which they were citizens. The experiment station is, without doubt, the proper place for such work to be done, and inasmuch as the General Government has given to each one of these stations substantial financial aid, it is only simple justice that this class of work be given to them. Although we have thus been relieved in part of the burden of routine work formerly imposed upon us, there has still been a large amount of miscellaneous work demanded, and the force of the Department has been unequal to keeping up with the work proposed. As a consequence of this the regular investigations of the division have been somewhat retarded on account of the necessity of permitting a part of the chemical force to engage in the miscellaneous work indicated.

ANALYSES OF FERTILIZERS.

Numerous analyses of fertilizers, fertilizing materials, clays and marls have been made in the division since our last report, but these appear to have only a local interest; and inasmuch as the results of the work have been sent by mail to the persons interested they are omitted from this report.

PRODUCTION OF BEET-SUGAR.

Since the report made in Bulletin No. 5, in 1885, on the production of beet-sugar in California, much interest has been manifested, not only in that State but in other parts of the United States, in the establishment of a beet-sugar industry. A large number of samples of beet seed was sent out by the Department last spring to different part of the United States, and we have received many samples of sugar beets for analysis as the result of this distribution.

These analyses are as follows:

From E. G. Church, Topeka, Kans., a sample of sugar beet with the following composition:

	Per cent.
Total solid matter	16.20
Sucrose	11.44

The low purity indicated by the above analysis is due doubtless to the fact that the beet had been harvested for a long time and had deteriorated somewhat from its original condition.

From A. H. Almy, Norwich, Conn., two samples of sugar beet, which on examination gave the following results:

No. 1.	Per cent.
Sucrose	3.87
Degree brix	8.60
Purity	41.00

No. 2.	Per cent.
Sucrose	7.90
Degree brix	12.30
Purity	64.23

These beets were very poor and unsuitable for the manufacture of sugar.

From the Empire Coal Company, Gilchrist, Ill., a sample of sugar beets of the following composition:

	Per cent.
Juice expressed	55.62
Total solids in juice	14.51
Sucrose in juice	11.30
Purity co-efficient	77.86

The above sample was of fair value for sugar-making purposes but not first-class quality. For the first year's experiment, however, it may be considered favorable.

From William M. Steer, West Branch, Iowa, a sample of sugar beets of the following composition:

	Per cent.
Juice expressed	58.74
Total solids	9.70
Sugar in juice	6.20
Purity co-efficient	63.91

These beets were of a very poor quality and unfit for sugar-making purposes. It is possible that the planting of the beets was too late and that they had not time to ripen.

From Ira Ford, Hastings, Nebr., of two samples of sugar beets which were analyzed with the following results:

No. 1, labelled A. F. Powers; soil, black sandy loam.
No. 2, labelled Lain's Imperial, grown by Fred Johnson; beets grown all in one row; the largest one weighed 6 pounds; planted April 23, 1889; harvested October 17, 1889; soil, black sandy loam.

	In the juice.	
	No. 1.	No. 2.
	Per cent.	*Per cent.*
Total solids	14.02	13.77
Sucrose	9.25	9.75
Purity co-efficient	65.90	70.80

From Gustav Onken, Chapin, Ill., four samples of beets, which on being analyzed gave the following results:

No. 1, six beets, raised by J. B. Kinnet, Chapin, Ill., on black prairie land; all beets grown in one row; plants at the distance of about 1 foot; no fertilizer used.
No. 2, seven beets, raised by B. H. Merrill, Chapin, Ill.; beets were raised in Scott County on barren timber land; no fertilizer used; plants all grown in one row, at a distance of about 1 foot apart.
No. 3, six beets, grown by Gustav Onken; planted the latter part of April, 12 inches apart each way; the beets were finally thinned until there were sixteen plants to the square yard; soil, black; no fertilizer was used; crop hoed four times.
No. 5, four beets, grown by Frank Burnham, on black soil; row 12 inches apart; no fertilizer used. There were about twelve plants on a square yard; the ground had been manured in 1888 in the spring, but not since then.

	In the juice.			
	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Total solids	12.17	14.02	7.62	11.32
Sucrose	8.40	9.50	4.05	7.10
Purity co-efficient	69.02	67.76	53.14	62.72

These beets are all of very poor quality, and not suitable for sugar making purposes.

From Harry F. Downs, Lincoln, Nebr., three samples of sugar beets, numbered 36, 34, and 40, which were analyzed with the following results:

No. 36, grown by Rollin Orcutt, Harmony, Nebr.; variety, Vilmorin; planted May 18, 1889; sandy loam soil; cultivated by the hoe; harvested October 10, 1889.
No. 34, grown by D. Windhusen, Pender, Nebr.; variety, Vilmorin; planted May 15, 1889; soil, black loam; cultivation same as for corn; harvested October 14, 1889.
No. 40, grown by A. S. Darling, Alliance, Nebr.; variety, Lane's Imperial; planted May 27, 1889; soil, black sandy loam; cultivation, plowing and hoeing; harvested October 21, 1889.

Analytical data.

	In the juice.		
	No. 36.	No. 34.	No. 40.
	Per cent.	*Per cent.*	*Per cent.*
Total solids	16.02	14.37	17.60
Sucrose	12.50	9.00	12.30
Purity co-efficient	78.02	62.63	69.88

From W. C. Buderus, Sturgis, S. Dak., four samples of sugar beets, analyzed with the following results:

No. 1 marked Alkali White.
No. 2 marked Sturgis White.
No. 3 marked Alkali Red.
No. 4 marked Bear Butte White.

Analytical data.

	In the juice.			
	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Total solids	16.20	14.87	19.37	22.25
Sucrose	10.75	8.50	13.55	17.00
Purity co-efficient	66.35	57.16	69.95	76.40

From the above analyses it is seen that Nos. 3 and 4 show beets having a very high content of sucrose, especially the latter, and capable of yielding a satisfactory amount of sugar if manufactured. The purity co-efficient of the samples is somewhat low, but this is doubtless due to the fact of the ground on which they were raised being fresh.

From Ira Ford, Hastings, Nebr., three samples of beets, analyzed with the following results:

No. 1, grown by Fred. Bates; light loam soil; variety, Lane's Imperial.

No. 2, grown by Fred. Rinker; soil, black sandy loam, an old clover pasture plowed in 1888; no manure; variety, Lane's Imperial; planted May 10; harvested October 25, 1889.

No. 3, grown by Fred. Bates; light loam soil; variety, Vilmorin.

Analytical data.

	In the juice.		
	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Total solids	8.90	17.07	14.20
Sucrose	6.00	12.50	10.20
Purity	67.41	73.22	71,80

From the above analysis it is seen that No. 2 contains a sufficient amount of sugar to make it valuable for manufacturing purposes. The other two fall below the standard, and No. 1 especially would be worthless for sugar-making. With such beets as No. 2 a yield of 150 pounds of sugar per ton could be reasonably expected.

From John Jenkins, Lincoln, Nebr., twelve samples of beets, which were examined with the following results:

No. 25, grown by Henry Nagle, Chicago, Nebr.; variety, Lane's Imperial; planted May 13; harvested October 10; soil, black sandy loam.

No. 27, grown by L. A. Gannon, Lodge Pole, Nebr.; variety, Vilmorin; planted April 27; harvested October 23; soil, dark sandy loam.

No. 35, grown by John Gabriel, Cedar Bluffs, Nebr.; variety, Vilmorin; planted May 25; harvested October 10; soil, black rich loam.

No. 38, grown by E. E. Adams, Mentorville, Nebr.; variety, Vilmorin; planted May 15; harvested October 10; soil, light sandy loam.

No. 39, grown by George M. Beor, Orleans, Nebr.; variety, Vilmorin; planted May 31; harvested October 18; soil, bottom land.

No. 41, grown by William Tweed, Bassett, Nebr.; variety, Vilmorin; planted May 25; harvested October 3; soil, sandy loam.
No. 43, grown by R. L. Grosvenor, Hoskins, Nebr.; variety, Vilmorin; planted May 25; harvested September 26; soil, sandy loam.
No. 46, grown by Edward Arnold, Odell, Nebr.; variety, Vilmorin; planted May 15; harvested October 26; soil, sandy loam.
No. 47, grown by Joseph B. Mourer, Aurora, Nebr.; variety, Vilmorin; planted June 1; harvested October 31; soil, light.
No. 49, grown by G. W. Alexander, Milligan, Nebr.; variety, Vilmorin; planted June 1; harvested October 25; soil, common prairie.
No. 51, grown by Joseph Lamb, Hubbell, Nebr.; variety, Vilmorin; planted May 23; harvested November 4; soil, black loam.
No. 48, grown by John Darr, Scottsville, Nebr.; variety, Lane's Imperial; planted May 28; harvested October 15; soil, sandy loam.

Analytical data.

	In the juice.					
	No. 25.	No. 27.	No. 35.	No. 38.	No. 39.	No. 41.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total solids	14.00	15.57	18.20	25.80	18.35	12.82
Sucrose	9.35	10.45	13.50	22.30	13.50	10.10
Purity	66.78	67.11	74.17	86.43	73.56	78.77

	In the juice.					
	No. 43.	No. 46.	No. 47.	No. 49.	No. 51.	No. 48.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total solids	13.07	10.35	16.20	14.52	6.92	15.37
Sucrose	9.00	6.50	13.50	10.65	3.55	11.40
Purity	68.85	62.99	83.33	74.73	51.14	74.16

From the above analyses it is seen that we have in these beets one remarkable sample, No. 38, which shows the highest content of sugar in the juice of any beet heretofore analyzed in the United States. In addition to this there are other excellent samples, namely: No. 35, No. 39, and 47, all of which would yield large quantities of sugar when properly manufactured. The other samples as indicated by the analyses are practically worthless for sugar-making purposes.

From John Jenkins, Lincoln, Nebr., two samples of sugar beets, which, on being analyzed, gave the following results:

No. 31, grown by B. Thompson, Swanton, Nebr.; variety, Lane's Imperial; planted last of May; harvested October 1; soil, black loam.
No. 53, grown by Wellfleet Land and Improvement Company, Wellfleet, Nebr.; variety, Vilmorin; planted June 1; harvested November 9; soil, sandy loam.

Analytical data.

	In the juice.	
	No. 31.	No. 53.
	Per cent.	*Per cent.*
Total solids	14.65	20.27
Sucrose	10.40	17.05
Purity	70.98	84.11

No. 53, as indicated by the above analyses, is a beet of very superior quality, and if a crop of the same kind could be grown and manufactured by the best methods, it would yield not less than 250 pounds of sugar per ton of beets.

No. 31 is of rather inferior quality and would not yield over 130 or 140 pounds of sugar per ton.

From the annotations accompanying the analyses it is easy to discriminate between the good and bad varieties which have been received. The general result of the work leaves little doubt of the fact that there are many parts of the United States peculiarly suitable to the production of a sugar beet containing a large percentage of saccharine matter.

CULTIVATION OF SUGAR BEETS.

For the benefit of many interested parties I will give here a short description of the method of raising sugar beets, together with the method of manufacture of sugar therefrom, and will refer those who are more particularly interested in the matter to a bulletin which is now in course of preparation and will be issued shortly by the Department devoted to the production of sugar from the sugar beet. Copies of this bulletin when published can be had by addressing a request to that effect to the Secretary of Agriculture.

Many varieties of beets are grown for the production of sugar, but these are all nearly related botanically, and the variations are based largely upon slight differences in the shape or color of the plant. The botanical name of the sugar beet is the *Beta cicla* or the *Beta vulgaris*, and different varieties which are now under cultivation have been developed from the original form by careful culture and selection. The different varieties of beets, as named in commerce, as has already been indicated, are determined by differences in size, color, and peculiarities of the leaves as well as in the differences in the size and color of the roots themselves. Some beets have their leaves standing upright, while others have them spread out over the soil; some leaves are smooth and others wrinkled; some are bright and others dark-green while the stems of the leaves are also of different colors. The roots are spindle-shaped, growing more or less towards spherical. The growing beet remains either entirely in the earth or is raised to a greater or less extent above the surface of the soil. The best beets for sugar-making purposes should have the following characteristics:

(1) The beet should be regularly spindle-formed to pear-shaped, with a simple and gradually tapering point and with as few as possible adhering rootlets to the sides.

(2) It should have a mean weight of from 1 to 1½ pounds. Smaller beets give too small a harvest and larger have generally a juice poorer in sugar.

(3) The interior of the beet should be white, hard, and firm. The beet should be a variety which grows as little as possible above the surface of the soil and should have a large number of leaves.

In Germany the chief varieties grown are the White Silesian, which is the most widely distributed and the highest priced; it is somewhat pear-shaped with broad leaves standing straight and with bright green stems. It has many subvarieties, among which the one with small crumpled leaves is the most highly prized.

The Quedlinburger is more slender, that is, more spindle-shaped,

with rose-colored head and reddish leaf-stems. It is better adapted for the heavy and richly manured soils, where the beets are grown closely together, while the Silesian is better adapted for poorer and sandier soils where the beets are grown wider apart.

The Imperial beet is slender, somewhat pear-shaped, with a white fine interior; the head small and growing entirely beneath the soil, with leaves bright green and upright and strongly wrinkled.

In France the beet known as the Vilmorin is the one which is most largely cultivated.

SOIL.

Any good soil is suitable for the growth of the sugar beet, but a sandy loam is perhaps best adapted for that purpose. The soil should be deeply plowed and thoroughly pulverized so as to allow the downward growth of the beet. Evidently a soil which is pulverized only to the depth of a few inches will not allow the tapering root of the beet to sink to a sufficient depth, and the result will be that the head of the beet will grow above the soil, thus exposing it to the dangers both of hot suns and early frosts.

CLIMATE.

For the production of the best class of sugar beets a cool summer is necessary. The effect of the hot suns of a warm summer climate is to soften the head of the beet even when it is carefully covered by the soil, thus rendering the storage of sugar in this part of the beet impossible. In the harvesting of such beets a large part of the top of the beet must be cut off in order to secure the remainder of a proper saccharine strength. Beets, however, grow very well on high plateaus, even in the southern climates, as in the neighborhood of Granada, Spain. During the past season beets were very successfully grown at Medicine Lodge, Kans., but the season was an exceptionally favorable one for the growth of beets, there being an absence of the hot winds which are so apt to prevail in that region during the months of July and August. The beets which were grown in that locality during the past season do not compare favorably with those grown in France and Germany, although the yield of sugar was satisfactory considering all the adverse circumstances.

As pointed out in Bulletin No. 5 of this division, the coast valleys of California are peculiarly suitable to the growth of the sugar beet, and later experiments have shown that many parts of Nebraska and Dakota also produce sugar beets of satisfactory saccharine strength. It is probable that the sugar beet area of this country will be found along the Pacific coast, on the high plateaus of Utah and Colorado, in certain parts of Nebraska and Dakota, in Southern Iowa, Minnesota, and Wisconsin, and in Northern Indiana, Ohio, and New York. Several years of experimenting will determine in what particular part of these localities the best soil and climate for the production of the sugar beet are to be found.

CULTIVATION.

The cultivation of the sugar beet is a matter of especial importance. The farmer who expects to grow a beet rich in sugar by simply planting the seed and plowing it a few times will be doomed to disappointment. The cultivation of the beet belongs rather to horticulture than to agriculture. It requires the frequent use of the hoe, careful

attention, and a close supervision, which it is not usual to give to field crops in this country.

The number of beets grown on a given area will depend largely upon the nature of the soil and the character of the fertilizer employed. In all cases the beets should be grown sufficiently close together to prevent any of them reaching a maximum weight of more than 2 pounds and to produce an average weight of about 1½ pounds. The number of beets per square yard to produce this result will vary from seven to fourteen. The beets should always be planted very thick and then thinned out when young to the proper distance to secure the number of beets above mentioned, according to the richness of the soil and the other conditions above noted. Aside from the hoeing and attention above mentioned, the cultivation of the beet is carried on much the same as any other field crop; the ground being kept pulverized and free from weeds until well covered by the leaves of the growing plants. The soil should also be thrown toward the beets in sufficient quantities to prevent them from protruding above ground.

HARVESTING.

The time for harvesting the beets usually begins about the 1st of October. They are to be thrown out of the soil by an appropriate plow, or beet digger built much upon the principle of an ordinary potato digger. The beets are then to be taken one by one and the leaves and a portion of the top taken off, which varies in extent with the position which the beet occupied in the soil. If the beet be grown well under ground only a small portion will be taken off with the leaves; if, however, it should protrude much above the soil a considerable quantity must be cut off. The tops of the beets contain very little sugar and a large proportion of the total salts of the whole plant, and it is important to secure a large yield of sugar by removing the proper amount of the top of the beet with the leaves.

After the beets have thus been harvested and topped, they are delivered either directly to the factory or else placed in heaps and covered with earth to protect them from freezing.

MANUFACTURE OF SUGAR BEETS.

It will be only necessary here to briefly indicate the nature of the process employed in the manufacture of sugar from the sugar beet; the details of the process, together with illustrations of the machinery employed will be found in the Bulletin already mentioned.

The beets delivered to the factory are first washed to remove all adhering dirt; they are then weighed and carried by an elevator to the slicing machine; this cuts the beets into appropriate pieces for the action of the diffusion liquids; the sliced beets are then carried by appropriate machinery to the diffusion battery, which resembles in every respect the battery used for the extraction of sugar from sorghum and sugar cane. After the extraction of the sugar the pulp is dropped on to appropriate carriers, then it is taken to the press, which removes from the pulp a large quantity of the water. The pressed pulp is then ready for cattle food, for which purpose it has considerable value.

The extracted juice is carried into large tanks, where it is treated with about 2.5 per cent. of lime; the lime is afterward precipitated by blowing through the liquid a stream of carbonic acid derived from

a lime-kiln attached to the factory. When the lime has all been precipitated the material is passed through a filter press, which separates completely the purified juice from all solid matters contained therein. In order to obtain a very pure juice this process of separation is repeated, sometimes twice. The pure juice thus obtained is evaporated to the consistency of a sirup in a vacuum multiple-effect apparatus. This sirup is then put into a vacuum strike-pan where it is crystallized and reduced to the proper degree of dryness. The mixed sugar and molasses from the strike-pan are carried to the centrifugal machine, where the molasses is separated and the sugar obtained in a dry state. The sugar thus obtained is what is known as raw sugar and is not yet fit for domestic use. If pure sugar is desired, bone-black filters are attached to the factory by means of which the juice is rendered pure and the sugar white.

The total cost of a complete apparatus for manufacturing sugar from sugar beets on a commercial scale will vary from $75,000 to $250,000, according to the size of the factory and the character of the buildings and machinery employed.

A sugar beet containing 12 per cent. of sugar will yield about 200 pounds of sugar per ton. A large quantity of sugar remains still in the molasses, and this is separated in various ways, either by the process of osmosis, by means of which the soluble potash and other salts in the molasses are removed, or by treating the molasses with strontia or lime and subsequently separating the sucrates of strontia and lime thus produced.

EXPERIMENTS IN THE PRODUCTION OF BEET-SUGAR AT MEDICINE LODGE, KANS.

The Medicine Lodge Sugar Company conducted an interesting sugar experiment in the production of beet-sugar, of which the following data are presented:

Number of acres planted	4.7
Tons of clean beets produced	60.23
Pounds of sugar made	10,158
Gallons of molasses made	380

Of the total sugar mentioned above, 2,800 pounds were second sugars. The cultivation received by the beets was as follows:

They were planted rather thick, and after they had come up they were thinned out to the proper distance The laborers had instructions to throw the dirt up around the beets after they were well grown. This part, however, of the instructions was neglected, and the consequence was that a portion of the beets grew above ground, and that part did not contain any saccharine matter, and had to be cut off with the tops, thereby causing a large waste. The beets were worked without many of the appliances usually found at a beet-sugar factory. They were washed by means of a hose, and cut by the cane shredder. The skimmings and settlings were run into the waste ditch, instead of being utilized. The beets were grown upon five different pieces of ground, within a radius of 2 miles of the sugar works, and all upon what is called second bottom soil. None of the plots was irrigated. The seeds were obtained in Germany by Mr. Hinze, and from 7 to 8 pounds were used in planting one acre of ground. The beets were planted the 1st of May, but should have been planted at least two weeks earlier.

The analytical data obtained in the experiments in the manufacture of beet-sugar are as follows:

	Date.	Brix corrected to 17.5° C.	Sucrose.	Purity.
			Per cent.	
Exhausted chips	Nov. 14	1.60	.62	38.75
Do	15	2.24	.82	32.14
Means		1.92	.72	35.14
Fresh chips	14	13.74	9.00	65.50
Do	15	12.09	9.67	71.71
Means		12.91	9.33	68.60
Diffusion juice	14	10.83	7.89	72.76
Do	15	10.99	7.37	67.16
Means		10.91	7.63	69.96
Clarified juice	14	11.64	7.77	66.58
Do	15	10.65	6.35	59.62
Means		11.14	7.06	63.20
Semi-sirup	14	25.26	18.10	71.61
Do	15	29.32	18.80	64.61
Means		27.29	18.45	68.11
Massecuite	16	85.68	49.31	56.39
Molasses	24	77.71	32.11	42.60
Raw sugar			90.90	
No. 16 reboiled sugar			99.90	

PRODUCTION OF SORGHUM SUGAR.

The Department of Agriculture during the past year has carried on extensive experiments in the production of sugar from sorghum. These experiments may be divided into two great classes: First, culture experiments, having for their object the production of new varieties of cane and the improvement of old varieties in sugar content; second, manufacturing experiments, including aid in furnishing new machinery to factories and in exercising a complete chemical control of manufacture.

The culture experiments were carried on at the following stations:

At College Station, Md., two plots were cultivated in different varieties of cane, one by Mr. D. M. Nesbit and the other by Maj. H. E. Alvord, the director of the Maryland Agricultural Experiment Station.

Mr. Nesbit's plot contained 5 acres, and the station plot 10 acres. These plots were laid off regularly into small parcels, and a great many different varieties of cane were planted thereon. The fertilizers employed had the following composition:

Description of samples.

No. 1..........Fine bone.
No. 2..........Corn guano.
No. 3..........Muriated potash.
No. 4..........Kainite
No. 5..........Ammonite.
No. 6..........Acid phosphate.
No. 7..........Ammoniated dissolved bone.
No. 8..........Ammonium sulphate.
No. 9..........Dried blood.
No. 10..........Thomas slag.
No. 11..........Nitrate of soda.
No. 12..........Dissolved bone-black.
No. 13..........Sulphate of potash.
No. 14..........Cotton-seed hull ash.

Analyses.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Moisture	7.44	15.78	.62	9.58	8.26	11.78	10.67
Total phosphoric acid	29.68	14.53	....	....	4.62	20.30	18.69
Soluble phosphoric acid	....	....	....	....	....	11.44	6.73
Reverted phosphoric acid	....	....	....	....	....	7.00	8.09
K_2O	....	....	49.97	12.37	....	....	....
Ammonia	4.59	2.24	....	....	15.12	.44	....

	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.	No. 14.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Moisture	....	....	.22	....	18.31	12.72	5.96
Total phosphoric acid	....	....	19.59	....	16.42	....	8.67
Soluble phosphoric acid	....	....	....	....	15.34	....	....
Reverted phosphoric acid	....	....	....	....	.74	....	....
K_2O	....	....	....	....	....	27.20	25.45
Ammonia	24.45	14.90	....	18.05	.82	....	....

The method of applying the fertilizers and the quantity per acre will be fully described in Bulletin No. 26, which is now in course of preparation and will be issued shortly.

On account of the extremely wet spring, planting was not commenced on the plots until late in May and not completed until late in June. The excessive rains continued during the entire season, making it almost impossible to cultivate the plants, many of which were entirely drowned out. The results were extremely unfavorable, the canes produced being poor in sugar, although in some instances the tonnage per acre was quite satisfactory. The general results of the experiments tend to show that sorghum as a sugar-producing plant is a complete failure in a wet season such as was experienced here in 1889.

The culture experiments at Sterling were conducted on a plot of about 35 acres, on which many different varieties of cane were grown. The season at Sterling was much more favorable and the results were quite encouraging. It was proved beyond doubt by the process of selection, commenced at Sterling by the Department last year, it was possible to distinctly improve the sugar-producing qualities of sorghum. Cane grown from seed selected last year on account of a high sugar content showed a distinct improvement in its sugar-producing properties, leading to the expectation of an early and permanent improvement in the varieties from an economic point of view. In general it may be stated that the production of new varieties is not so much desired as the improvement by selection, proper cultivation, and fertilization of the varieties already known.

In regard to the fertilization it is unfortunate that the wet season spoiled the experimental attempts at the Maryland Station for determining the effect of different fertilizers and mixed fertilizers upon the sugar-producing quality of the plant. It is to be hoped that this experiment may be continued in coming years in order that this point may be definitely determined.

At the Sterling Station no fertilizers were employed, the natural fertilization of the soil alone being relied upon to produce the crop. It must not, however, be expected that sorghum, as a sugar-producing plant, will have a history different from other plants grown for that purpose. No matter how fertile the original soil may be the

time will soon come in the course of cultivation when artificial fertilizers must be resorted to in order to produce a paying crop. It is far better to get a few acres of heavy canes rich in sugar than many acres of light canes poor in sugar. When it is considered that if we can produce a sugar-producing plant which will yield from 150 to 250 pounds of sugar per ton and a yield of 10 to 15 tons of plants per acre, only a few millions of acres of land will be necessary to produce the entire sugar supply of the country, the importance of seed selection and fertilization from an economic point of view is at once rendered prominent. In view of all the data which has been collected by the Department it is proper to say that future experiment of a public nature in the production of sugar from sorghum lies almost wholly within the lines of work above indicated. It has already been demonstrated that certain kinds of machinery are most effective in the production of sorghum sugar, and the locality has been pretty definitely pointed out in which the plant grows most favorably. It remains, therefore, for the Department to pursue its investigations in the improvement of the cane, in order that the farmer may have placed in his possession the proper varieties of seed for the production of a plant having the maximum content of available sugar. If, in addition to this, certain experiments are conducted looking to the more perfect separation of the sugar from the molasses, the Department will have done all for the grower and sorghum sugar manufacturer that can be reasonably demanded. The full details of the culture experiments at Sterling will be found in the forthcoming Bulletin No. 26.

MANUFACTURING EXPERIMENTS.

This class of experiments has been conducted by the Department at the following points:

Cedar Falls, Iowa; Rio Grande, N. J.; Morrisville, Va.; Kenner, La.; Medicine Lodge, Attica, Conway Springs, Liberal, Arkalon, Meade, Minneola, and Ness City, Kans. In addition to the above places the machinery belonging to the Department at Fort Scott, Kans., has been used by the Parkinson Sugar Company at that place, although the Department has furnished no financial aid or chemical control for the work there.

The full details of all the above experiments will be given in Bulletin No. 26.

The general results of the manufacturing work have been disappointing in their nature. So far as the economical production of sugar is concerned, it may be said that the experiments at Cedar Falls, Rio Grande, Morrisville, Kenner, Liberal, Meade, Arkalon, Minneola, and Ness City were decided failures. At Fort Scott, Conway Springs, and Attica an amount of sugar was made which may be roughly given at 350,000 pounds for each place. At Medicine Lodge a decidedly larger amount of sugar was made, which, from present advices, will reach nearly 500,000 pounds. Returns from these stations of an economic nature have not yet been received, so it is impossible to state whether or not these factories have been run at a profit. From information already at hand, it would seem that one of them at least, viz, Medicine Lodge, has produced sugar, if not at a profit, certainly nearly so. It must not be forgotten, however, that in all these localities in Kansas a State bounty of 2 cents per pound is given, which it is not expected, nor probably desired, should remain permanently in force. It can not, therefore, be said with

truthfulness that the sugar industry is economically successful until it is rendered independent of this *pro tempore* aid.

It may be of interest to give here a few of the general results obtained in each of the localities where manufacturing experiments were carried on.

CEDAR FALLS.

From the reports made in 1888 by the Iowa Agricultural Experiment Station it was thought by many of the farmers of that State that sorghum sugar could be produced at a profit. This theory was strongly contradicted by the facts previously set forth in the publications of the Department, which show that in a latitude as far north as Iowa it is hopeless to expect the establishment of a successful sorghum sugar industry. Although it is true that certain early varieties of sorghum cane may be grown and matured in the State, yet it is likewise true that early frosts and the early advent of winter prevent a manufacturing season of sufficient length to justify the expectation of success in the manufacture of sugar from a plant so capricious as sorghum. Nevertheless, in order to satisfy the demands of the Iowa farmers, $5,000 was set aside for conducting experiments in the manufacture of sugar, and this money was spent under the direction of the Bozarth Bros., of Cedar Falls, who have for many years successfully carried on a sorghum sirup factory at that place. The proper machinery for manufacturing sugar was added to the factory and the attempt made to manufacture sugar, but, as was expected by the Department, without success. Very little sugar was made, and the early close of the season, due to a short crop, prevented the continuation of experiments in this direction. The claim which has been persistently made in some quarters, that sorghum can be successfully grown in any locality where maize will produce a crop, is certainly not warranted by the facts and is calculated to mislead capital and to excite hopes among agriculturists which can not be realized. I deem it, therefore, my duty to speak plainly on this subject and to warn both farmers and capitalists in regard to the dangers of investing in sorghum sugar factories in high northern latitudes.

RIO GRANDE.

The experiments in the manufacture of sugar at Rio Grande are of chief value on account of the light which they throw upon the gradual deterioration of the cane at that place. It is a remarkable fact that although the experience of years has served to guide both farmer and manufacturer, nevertheless the results of the year's work are less hopeful of future success than any of the previous years. With the exception of a very small plot containing 2.9 acres, the cane at Rio Grande was totally unfit for sugar-making. This was probably largely due to the wet and cloudy season, although it but confirms the results obtained in the last few years at that place. The cause of this deterioration of the sorghum is not well understood. It can hardly be due to admixture with broom-corn, since no such admixture is known to have taken place. It may be due to the fact that the sorghum at Rio Grande has developed a tendency to the production of large quantities of seed to the deterioration of the cane, as ascribed to this cause by Mr. Horton, my assistant at Rio Grande. It is more probably due to insufficient heat and light. The history of the plot from which the sugar was made is as follows:

The field has been in sorghum cane during the seasons of 1882, 1883, 1884, 1885, and 1886, and the present season. In 1887 and 1888 clover was grown on this plot and the clover plowed under. The planting of the plot was finished on the 15th of May. Some replanting was required, which was finished on June 7. The fertilizer employed was "specific guano" at the rate of 150 pounds per acre, which was put in the hill. The cane was twice cultivated and the weeds were pulled out thoroughly in August. The cane received no hoeing. The average percentage of sucrose in the juice from the 2.9 acres was 11.14. The amount of sugar made was 2,900 pounds, or 1,000 pounds to the acre. The sugar was of a low grade, polarizing about 84.

In general it may be said that in 1889, on account of the wet spring, the attempt was made at Rio Grande to make up for late planting by the use of forcing fertilizers. This favorable result shows what may be accomplished when the same conditions can obtain over the whole plantation as were found in the small plot. It is quite remarkable, however, that other parts of the same field, which in all respects had been treated as the plot which produced the sugar, failed to develop as rich a cane and consequently the amount of sugar produced from the other parts of the field was insignificant in quantity. On the whole it must be confessed that the production of only about 3,000 pounds of sugar in the whole season's work and from 200 acres of cane is not at all encouraging.

MORRISVILLE.

The history of the experiments at Morrisville is only a repetition of the difficulties, so far as field work is concerned, that were encountered in Maryland and New Jersey. The season was one of continuous rains and the planting and cultivation of the crop was necessarily conducted in the mud. At Morrisville the rains, after a portion of the planting had been accomplished, were so heavy that over acres of ground the seeds were utterly washed out and the seeding had to be done again. The varieties planted were Early Orange, Link's Hybrid, Late Orange, White African, Early Amber, and Improved Orange. The planting commenced about the middle of May and was not completed until the end of June. By reason of this late planting by the beginning of September the best plots of cane, although healthy in appearance, were undergrown and uneven. The late planted plots, certain of which were more even, could only become developed to a sugar-making value under the influence of a long and mild autumn.

The machinery was hastily constructed and imperfectly put together, and even had the cane been suitable for sugar-making purposes it could not have been profitably worked. The numerous analyses disclosed an average of sucrose in the juice of the cane from the 151 acres examined of only 7.3 per cent. The averages of sucrose of the different varieties were as follows:

	Per cent.
Early Amber	5.5
White African	9.3
Early Orange	7.4
Late Orange	8.4
Improved Orange	7.9
Link's Hybrid	10.1

Of the Link's Hybrid, which proved to be the best variety of cane, only 4½ acres were grown, while of the Early Amber, which proved to be the poorest, 53 acres were cultivated. The crops of sorghum grown by farmers near the factory gave much better results than the crop grown by the company itself. The average of ten different plots grown outside of the company's land showed an average content of sucrose of 9.9 per cent. in the juice of the cane; this indicated a crop which might yield from 60 to 70 pounds of sugar per ton.

Although the season's results were unfavorable, the fact that in some instances farmers produced crops containing a considerable percentage of sucrose would indicate that in Virginia sorghum might, under a careful cultivation and study of its habits, become a paying plant for sugar-making purposes. Unless, however, the average of the crop can be considerably improved there is no early expectation of the realization of this hope.

KENNER.

The experiments in the manufacture of sugar at Kenner were conducted on a smaller scale than those which have previously been noted. They were made at the sugar experiment station of Louisiana by Dr. W. C. Stubbs, the director of that station. Examinations of the canes were made beginning on July 30 and continuing until August 25, and a study of the percentages of sucrose therein made during those intervals. Studies were also made of different varieties of cane grown on the State Experiment Station at Baton Rouge, in some of which large percentages of sucrose were found. Other varieties were also grown on the North Louisiana Experiment Station, at Calhoun, with a uniformly large percentage of sucrose in the juice and a high co-efficient of purity.

Sugar-house results.—The diffusion battery employed at Kenner consisted of fourteen cells, each with a capacity of 13½ cubic feet. The clarification of the juice was practiced by adding lime to the cell, and this clarification was performed with varying success, depending entirely upon the heat obtained. When clarification was not completed in the cells it was finished in the clarifiers. From the clarifiers the juice was conducted to a double-effect vacuum pan and evaporated to a sirup; the sirup was sent then to the vacuum strike-pan, where the concentration was completed. The manufacture of sugar from sorghum commenced on the 4th of September in a trial with Early Amber. This sorghum was badly injured by the cane-borer. The entire interior of the stalk was red, and both the mill and diffusion juices were intensely red, which color could only be discharged by filtration through bone-black. No sugar was made from this first run, but only sirup. On September 5 another trial run was made on the Early Amber from the same plot. The analysis of the juice showed 8.3 per cent. sucrose and 4.71 per cent. of glucose. Only sirup was made from this run. On September 9 another run was made with Early Orange grown from seed raised at the station. This cane was cut on the 4th of September, at which time it showed 7.1 per cent. sucrose and 4.70 per cent. glucose; it was left in the yard in the open air until the 9th of September when the analysis showed 5.6 per cent. sucrose and 5.6 per cent. glucose. This was therefore deemed unfit for sugar making and was only boiled to sirup.

On September 10, Early Orange, Kansas Orange, and New Orange

were diffused; the juice was colored slightly red. An attempt was made to make sugar from this, but without success. It was therefore boiled to string proof; placed in the hot room, where it remained for three weeks; it was then passed through the centrifugal, where it yielded 62 pounds of brown sugar per ton of cane. The average percentage of sucrose in the juice from which this sugar was made was 9.7, and of glucose 2.85 per cent. The sugar made polarized 82.3 per cent. On September 13 experiments were made with Link's Hybrid, and the yield was 85 pounds of sugar to the ton, polarizing 94.7 per cent. The mean composition of the juice from which this sugar was made was 10.1 per cent. of sucrose and 2.12 per cent. of glucose. On September 22, further experiments were made with different varieties of cane, but all having low percentages of sucrose, so that no sugar was made from them. On September 24 sorghum was shipped from Baton Rouge to Kenner. Several of the best varieties were selected for this shipment; the cane was of excellent quality, fine size, and in the right stage of maturity; it was harvested and shipped on one day and worked up on the next; the juice was clear, diffusing easily, and boiling well. It would not, however, granulate in the strike-pan without assistance, and accordingly a small amount of crystallized sugar was added to the sirup. The sirup made was dried with difficulty, yielding 119.8 pounds per ton. The average composition of the juice from which this sugar was made was 11.3 per cent. sucrose and 2.42 per cent. glucose. The cane grown in Madison Parish and shipped to the station was worked on September 22 and gave 98 pounds of sugar to the ton. The average composition of the juice from this sample was 9.25 per cent. sucrose and 3.57 per cent. glucose. In regard to the general character of the work Professor Stubbs makes the following comments:

The sorghum grown at Kenner was of an inferior character; that grown at each of the other stations and at Mr. Maxwell's very fine.

The soils of each of these places vary greatly. At Kenner the soil is a black, heavy, tenacious clay, hard to cultivate and harder still to drain, susceptible of injury from either extreme of drought or excessive rain-fall. Small seed, if not too deeply planted, germinate quickly in it. At Baton Rouge the brown loam of the bluff formation prevails; a soil which withstands drought well, but can not endure excessive rain-fall. Small seed are with difficulty germinated; due to the soil puddling and forming an impervious crust after every shower. It works with ease, but it is difficult to drain. At Calhoun there exist the sandy and loamy tertiary soils, easily worked and drained; a soil whose physical properties are good, and which needs only proper fertilization to make excellent crops in propitious seasons. At Mr. Maxwell's we have the typical alluvial soil of the Upper Mississippi bottoms; a sandy soil easily worked and drained and of great fertility. These four soils well represent all the soils of the State, save the red lands of Red River bottoms and the light prairie fields of southwestern Louisiana.

The seasons at each of these places varied greatly during the period of the growth of sorghum. At Kenner a prolonged drought, following a heavy rain-fall of April 13, greatly injured the sorghum, making it small and spindling. When the rains began on last of June it produced suckers, greatly to the detriment of the cane. The cane-borer also attacked the sorghum at Kenner and did it considerable damage.

The same drought prevailed at Baton Rouge, but the seed implanted in April did not germinate until June, and hence the young plants were not stunted as at Kenner. No worms or suckers interfered.

At Calhoun most propitious seasons prevailed and the canes were fair in quantity and quality.

At Mr. Maxwell's fine seasons prevailed in the early growth of the cane, but near maturity a prolonged drouth was encountered, which doubtless injured the cane.

In reviewing the agricultural results, it may safely be asserted that dry, well-drained, loamy soils are best adapted for sorghum and that showers at regular intervals favor a large sugar content as well as tonnage. Neither drouths nor excessive rain-falls are favorable to a full development of this plant.

Another feature worthy of note: Only certain varieties of sorghum have given good results anywhere. Link's Hybrid, originated by Mr. Ephraim Link, of Greenville, Tenn., seems to have succeeded better on a large scale than any other variety. Of the one hundred varieties tested this year for the first time only a very few are worthy of further trial.

The sugar-house results were disappointing. In every instance difficulty was experienced in graining in the pan. Only by the addition of crystallized sugar or by the withdrawal for some time of heat could graining be started. Even at a temperature of 120° Fahr., with a vacuum of 26 to 28 inches, no grain could be formed. Does our sorghum contain more dextrine and soluble starches than that raised in Kansas? Or did we diffuse at too high a temperature? Our records show temperatures ranging from 40° to 80° C. in our dischaging tanks, and yet no preceptible difference in the sirups. Samples of all the molasses have been kept to further study their compositions.

Our greatest difficulty was in purging our massecuite; a great surprise to all. After running the centrifugal some time it was found on examination that a layer of sugar adhered to the sieve, upon which rested a layer of molasses, and this in turn was covered by a layer of white foam giving the appearance, while the centrifugal was in motion, of a beautiful white sugar. After stopping the centrifugal these layers had to be broken down and mixed with a little water and again centrifugalled. In this way a good sugar was obtained, but only at the expense of time, patience, and considerable loss of sugar.

CONWAY SPRINGS.

The factory at Conway Springs was transferred during the early part of the year from the original Conway Springs Sugar Company to the Kansas Sugar Company, which operated the plant during the season just past. The new company undertook to improve the plant and contracted with the Kilby Manufacturing Company, of Cleveland, for $30,000 worth of new machinery. In addition to the battery used the first year a second battery was constructed, so that the factory was operated with two small batteries instead of one large one, thus increasing the expense and complication of the work. The new machinery was not tested until the 25th of August, and the usual delay in the starting of the machinery was experienced. Warned by the experience of last year, the company undertook to procure pure water for the diffusion battery and for use in the boilers, through a 4-inch pipe line laid to a creek one mile away. Unfortunately the machinery which raised the water from the well had not been put in proper condition and considerable loss of time was caused by its failure to do the work at the commencement of the season. In addition to this the water supply was deficient, the water which came in through the pipe line not being in sufficient quantities to meet the purposes of the house.

Several weeks were lost on account of this insufficient supply, the work in the meantime lagging, so it was necessary to run first one part of the house and then wait until the other had caught up. Finally a pond was constructed near the mill and the waste water used over again for condensing purposes. As a result of all these imperfections the season's work was one continuous interruption. All these delays were caused by defects patent from the beginning, and which past experience should have induced the company to provide against. The greater portion of the month of September was consumed in this way and only about 1,500 tons of cane were cut, enough only for one week's work of the factory properly conducted.

These troubles appear to have brought about a general demoralization, and during the month of October, although the work was somewhat more steady, there were many delays caused by breaking drags, elevators, and pumps and other accidents, the result of gross carelessness, and some perhaps unavoidable. The double effect

caused some delay by the tubes becoming coated with scale, necessitating the removal of the heads of the pans and the scraping of the tubes.

The exhausted chips were removed from the battery by means of carts and dumped on the adjacent prairie. Four two-horse carts, with drivers, and six additional men were employed for this work, a daily expense of about $19—a very much larger expense than would be necessary if proper arrangements were made for the disposal of the exhausted chips.

The chips furnished to the diffusion battery by the cutters in the early part of the season were very fine and in excellent condition for diffusion. Later the knives became badly broken from stones and pieces of iron which found their way to the shredders, and little attention was paid to setting and grinding the knives properly; hence, with a very large dilution only a moderate extraction was secured.

The new battery gave better results than the old. This was due partly to the shape of the cells of the new battery, narrowing toward the top with a small top door, but chiefly it was due to the larger juice pipes and better circulation thereby secured.

In general it may be said that the heavy machinery was entirely adequate and suitable for the work, and that the delay and trouble should not be charged to this, but rather to carelessness and inexperience, and the breakages and imperfections in the smaller parts of the machinery which ordinary care in the preparation of the machinery should have avoided.

The character of the cane worked.—The character of the cane worked for sugar at Conway Springs was rather above the average for sorghum. The average composition of the juice taken from samples of the fresh chips as they entered the batteries for the whole season was as follows:

	Per cent.
Sucrose	11.98
Glucose	1.70
Total solids	18.33

These figures show a juice well suited for sugar-making purposes, and which, worked as closely as possible with ordinary appliances, ought to yield fully 120 pounds of sugar to each ton of fresh chips.

As indicated by the analytical work in the early part of the season, but little inversion of sucrose was noticed in the battery. Later this inversion was greater, and it was decided and deemed advisable to add sufficient lime to the chips in the battery to correct this. The skimmings and settlings were returned to the battery. The clarification of the juice was aided by liming to neutrality or nearly so and heating to the boiling point in open clarifiers. Some inversion was noticed between the clarifying juice and semi-sirups. This was due chiefly to the manner in which the juice was handled, which for a long time was allowed to stand for the purpose of settling before evaporation. The purity of the sirups was fair, and these sirups were grained without difficulty in the vacuum strike-pan. The sugar was boiled to a very fine grain, and this fact, as well as the inexperience of the workmen and the little attention paid to keeping the hot room to the proper temperature, caused the work with the centrifugals to be slow. The sugar also was heavily washed and a great deal of the fine portion found its way through the screens of the centrifugal into the molasses. The molasses therefore was found to be very rich in sugar, corresponding to the small yield of fresh sugar.

The total number of battery cells filled was 5,723. The old battery cells contained an average of 1,262 pounds per cell and the new battery 1,473 pounds, giving a total of 3,944.8 tons of chips which were diffused. The scale book of the factory shows that 4,596 tons of topped cane passed over the scales; 100 tons of this were unworked, some of it having spoiled while on the rack and the remainder being left in the shed when work was stopped. The total number of tons of topped cane worked was 4,496. From this cane were obtained 1,360,510 gallons of juice containing 711,801 pounds of sugar. This gave 228,800 gallons of semi-sirup containing 647,511 pounds of sugar. Sixteen thousand gallons of juice were lost by souring and waste containing 8,371 pounds of sugar. The battery work was interrupted and the battery drawn off 59 times, causing the loss of sugar from at least 60 tons of cane or about 6,000 pounds. The total loss of sugar in manufacturing may be tabulated as follows:

Loss of sugar by inversion	lbs..	64,290
Loss of raw juice	do..	8,371
Loss of sugar by drawing off of battery	do..	6,000
Total loss from diffusion to sirup	do..	78,661
Total fresh sugar made (*circa*)	do..	230,000
Molasses made	galls..	68,035

Of this molasses 8,424 gallons were sold and the remainder reboiled for sugar. The sugar contained in the reboiled molasses, viz, 58,611 gallons, amounted to 300,845 pounds. The quantity of sugar which the reboiling should give under the usual computation would be 156,388 pounds. Up to the present time the quantity of sugar obtained per ton of cane by reboiling is about 30 pounds. If the same rate is secured in the remaining portion of the molasses the yield of sugar at the factory during the year will be 363,570 pounds, and of molasses 48,566 gallons. Based upon the tonnage of the cane worked the yield would be 81.5 pounds of sugar per ton, and 10.9 gallons of molasses per ton.

The amount of sugar left in the chips was very large considering the dilution, and was due entirely to the very large chips furnished by the macerators to the diffusion battery.

The average percentage of fiber in the cane, as given by the analysis of the chips, was 11.49, which indicated the presence of 88.51 per cent. of juice in the cane. In the 3,954.8 tons of chips the amount of juice was 3,499 tons. This juice contained an average of 11.98 per cent. of sucrose, or in all 838,440 pounds, which would therefore leave in the chips 126,639 pounds of sucrose, or about 32 pounds of sugar to the ton of chips.

If the cane had been properly shredded this additional 126,639 pounds of sucrose would have been largely secured in the diffusion juice.

The company contracted with the farmers for 1,800 acres of cane; of this 200 acres were to be Early Amber and the remainder Orange. The company furnished the seed, and the greater part of the cane was planted on plowed land. The cane was not planted until May, and a number of acres had to be replanted, as the first planting was blown out. The season was unusually wet, the growth of the cane very rank, and the stalks large, averaging 14 feet in height. The tonnage was heavier than last year, the Amber giving 11 tons and the Orange 13 tons per acre when topped. Several hundred acres were planted on very poor land and did not mature; the remainder was fairly even in character. Owing to the late date at which the cane

was planted and the wet season, it did not mature until late. The greater part of the Amber cane was worked before it had attained its maximum content of sucrose. The Orange cane was at its best, as was the case last year, about the middle of October, after a light frost sufficient to kill the leaves.

Last year the richness of the cane was attributed partly to the dryness of the season. The present season was one having the largest rain-fall known in Kansas, and yet the average percentage of sucrose was 11.98 and of glucose 1.78; the average for 1888 being 12.42 and 2.61 respectively. This agreement in the content of sucrose is important from an agricultural point of view when the opposite characters of the two seasons are considered. The seed from last year's crop had been carefully hand picked and threshed from the richest plots of last year, and from this source the Medicine Lodge and Attica factories obtained most of their seed.

In this connection it is important to note the results obtained from Amber cane. The seed was selected from a plot which last year showed a sucrose content of 14.09 per cent. and glucose 1.26 per cent. This year seed producing a cane showing 13.10 per cent. of sucrose was planted on unplowed land and 13.20 per cent. on plowed land. In all cases there was a decrease in total solids as compared with last year and there was a corresponding increase in the purity of the juice. It was also noticed, this season as well as last, that while the Amber cane deteriorated rapidly if left any length of time after being cut, the Orange cane after it had attained its maximum content of sucrose was fairly stable. Several hard freezings did not materially injure the cane, as can be seen by the analyses made during the latter part of the season.

The factory was forced to stop cutting on the 8th of November for reasons which will be mentioned further on.

About 600 acres of cane of excellent quality were left standing in the field. About November 4 there was a light fall of snow, but this did no damage to the cane. The total number of days actually worked, counting 22 hours per day, was 45; that is, the work should have been done in that length of time if the mill had been run continuously.

The expense for labor and coal was enormous and might have been greatly reduced with proper care.

In summing up the results of this season's work, it is but fair to mention that the expense for labor and coal could scarcely have been a cent more if the mill had run steadily and done four times the work.

The assets of the company were:

Machinery and plant of the Conway Springs Sugar Company, including water works, actual value	$18,949.00
New machinery furnished by Kilby	30,500.00
Lumber, labor, etc., to put plant into shape for season's work	18,949.00
Total cost of plant	69,449.00
Expense account, including interest	1,830.00
Expenses during season.	
4,596 tons of cane, at $1.50	6,894.00
Labor, including salaries	9,100.00
Coal and oil	3,500.00
Incidentals	869.00
Barrels	680.85
Total	21,043.85

Receipts.

230,000 pounds of sugar, at 6 cents	$13,800.00
67,035 gallons of molasses, at 10 cents	6,703.50
	20,503.50
State bounty, 2 cents per pound	4,600.00
	25,103.50
	21,043.85
Profit	4,059.65

Interest on investment of 5½ per cent.

The United States Government gave to this company $8,000 for the purchase of machinery; so that the actual amount of money for which the stockholders were liable was $63,279. Owing to the fact that these stockholders were not able to meet the obligations for their shares of stock when payments were due and lacked ready capital to run the business, it was necessary to stop work. When, however, the product is all sold, including the State bounty, a small percentage upon the investment will be shown.

This poor result should not be blamed upon the industry but upon the people who engaged in it without financial resources.

For this reason again we have gone into the particulars of the troubles in order to show that it is not the fault of the business but of the way in which it is run that no better results have been secured. We do not intend any personal reflection, but deem it but fair in justice to the industry to state what we have.

In 1888 we made the statement that a great success could be secured at Conway Springs, provided improvements were made in the machinery and the management was good.

Though good machinery was purchased from the Kilby Manufacturing Company it was not all advantageously placed, and there was lacking the necessary experience to make the work successful. When some man or men with money select a site in the section of the State of Kansas near Conway Springs, erect an improved and substantial plant where there is an abundant pure water supply, and run it on legitimate business principles, with the intention of being satisfied with a good interest on the investment, then the sorghum sugar business in Kansas will be profitable both for investor and farmer.

The results of the trial run made from October 27 to November 1 were: 639.6 tons of cane worked, giving 47,944 pounds of sugar and 9,640 gallons of molasses, or 74.9 pounds of sugar and 15 gallons of molasses per ton of cane. From the molasses by reboiling an additional 30 pounds of sugar per ton and 8 gallons molasses were obtained, making per ton of cane 104.9 pounds sugar and 8 gallons molasses.

Expenses.

639.6 tons of cane at $1.50	$959.40
Four days labor	613.20
Coal	200.00
Incidentals	25.00
Barrels	30.00
Total	1,847.60

Receipts.

47,944 pounds of sugar at 6 cents	$2,876.64	
9.640 gallons of molasses at 10 cents	964.00	
		$3,840.64
Profit		1,993.04

This of course does not take into account interest on the investment, but shows that if a factory is run steadily money must be made.

The figures showing the respective percentages in the material and products of this run can be seen from the table:

Total number of tons of cane purchased	4,596
Total number of tons of cane worked	4,496
Number of tons of chips	3,954.8
Number pounds of sugar in chips	838,440
Number pounds of sugar obtained in diffusion juice	711,801
Number pounds left in chips and lost by inversion	126,639
Number pounds of sugar in semi-sirup	647,511
Number pounds of sugar in juice lost	8,371
Number pounds of sugar lost, attributable to inversion	64,290
Number pounds of sugar obtained firsts	230,000
Number pounds of sugar in molasses, less molasses sold	300,845
Available sugar in the molasses	156,388
Pounds of sugar in the molasses sold	43,226

ATTICA.

The character of the cane worked for sugar at Attica during the season can best be judged by the summary of the analyses taken in monthly periods during the course of manufacture. For August and September the mean composition of the juice of the cane sampled at the battery was as follows:

In the juice.

Sucrose	per cent..	9.95
Glucose	do....	2.29
Total solids	do....	15.96
Juice in the cane	do....	88.70
Cane received	tons..	2,197.2
Total sugar in the cane	pounds..	321,942.00
Total glocuse in the cane	do....	75,850.00
Total available sugar	do....	208,167.00
Sugar per ton of cane	do....	176.20

The data for the month of October are as follows:

In the juice.

Sucrose	per cent..	12.69
Glucose	do....	1.51
Total solids	do....	17.72
Juice in cane	do....	88.70
Cane received	tons..	1,914.00
Total sugar in the cane	pounds..	426,552.00
Sugar per ton of cane	do....	231.10
Total glucose in cane	do....	43,972.00

For November:

In the juice.

Sucrose	per cent..	12.13
Glucose	do....	1.36
Total solids	do....	17.41
Juice in cane	do....	88.30
Cane received	tons..	591.6
Total sugar in cane	pounds..	127,347.00
Glucose in cane	do....	13,804.00
Sugar available	do....	106,643.00
Total sugar per ton of cane	do....	214.10

Summary for the whole season.

Clean cane received	tons..	4,702.8
Field cane received	do ...	7,184.00
Loss in cleaning cane	per cent..	34.53
Average per cent. of juice in cane	do....	88.60
Total sugar in cane	pounds..	875,841.00
Total glucose in cane	do....	133,626.00
Sugar per ton of cane	do....	186.20

In regard to the working of the battery and the degree of extraction obtained, the following data may be cited:

For August and September:

Mean sucrose in exhausted chips	per cent..	.63
Dilution	do....	30.30
Extraction	do....	89.80
Loss of sugar per ton	pounds..	17.20

For October:

Mean sucrose in exhausted chips	per cent..	1.59
Dilution	do....	34.00
Extraction	do....	85.70
Loss of sugar per ton	pounds..	31.50

For November:

Mean sucrose in exhausted chips	per cent..	1.46
Dilution	do....	36.10
Extraction	do....	86.40
Loss of sugar per ton	pounds..	29.10

For the season:

Mean sucrose in exhausted chips	per cent..	1.22
Mean dilution	do....	31.50
Mean extraction	do....	87.30
Mean loss of sugar per ton	pounds..	25.90

In regard to the inversion which took place during the process of manufacture the following data may be cited:

For August and September:

Total inversion	pounds..	9,096.00
Inversion per ton of cane	do....	8.10
Sucrose in fresh chips inverted	per cent..	2.80

For October:

Total sugar inverted	pounds..	3,626.00
Inversion per ton of cane	do....	2.10
Sucrose in fresh chips inverted	per cent..	.85

For November:

Total inversion of sugar	pounds..	1,619.00
Inversion per ton of chips	do....	2.80
Sucrose in fresh chips inverted	per cent..	1.27

Means for the season:

Total inversion of sugar	pounds..	14,341.00
Sucrose in fresh chips inverted	per cent..	1.64

From the records of the company as received on the 16th of December, the total cost of fuel, exclusive of the seed burned for fuel and the fuel used in working second sugars, was $2,791.32; total cost of labor, exclusive of construction and labor used in boiling seconds, $9,987.58; the total product of first sugar, 262,038 pounds.

Estimating the yield of seconds at 30 pounds per ton, which is, considering the richness of the molasses, a moderate estimate, the quantity of second sugars obtained at this factory would be 141,060

pounds. Adding this to the product of first sugars, viz. 262,038 pounds, the total yield of sugar would be 403,098 pounds. The yield per ton of clean cane on this estimate would be 85.3 pounds, and the yield per ton of field cane, including the seed heads, would be 56.4 pounds.

The usual difficulties and delays in manufacturing sorghum sugar were experienced by this company, including, at the beginning, scarcity of water and other minor delays due to deficient working of different parts of the machinery. The average number of tons of field cane worked per day was only 97, whereas before the opening of the season it was supposed that the factory had a capacity of 250 tons per day. This failure of the factory to work up to its capacity was one of the chief causes of the financial troubles into which the company fell. On account of these financial troubles, on the 19th of October the Kansas State Sugar Company, at Attica, passed into the hands of a receiver.

When the richness of the cane worked is considered we must justly charge the failure of the company to secure a profit on their work to the mechanical difficulties encountered in the manufacture and the losses experienced due to deficient machinery and the inexperience of the workmen. In no other way can we satisfactorily explain the small yield of sugar per ton on cane of such uniform richness and good quality as was grown at Attica during the past season. At the time of closing the factory, the 12th of November, a large quantity of cane still remained in the field and of good quality for sugar-making purposes. This cane was of course lost, and the stoppage of the factory was due solely to the financial difficulties of carrying the work further, although the cane was commencing to deteriorate. With anything like a fair working of the house, the whole of the crop should have been worked up by the 1st of November, and the total amount of sugar made in this case would greatly have exceeded the amount obtained.

It is but fair to say that had the cane crop at Attica been worked promptly, with the proper machinery and at the proper rate per day and with the economy which ought to have been secured, the quantity of sugar made would have probably reached 600,000 pounds and the season's work shown profit instead of a deficit.

Full details of this work will be found in Bulletin No. 26, already noted.

MEDICINE LODGE.

The results of the manufacture of sugar from sorghum at Medicine Lodge were in every respect the most satisfactory of those obtained anywhere else during the season. The latest advices, December 11, which we have from this place show that about 500,000 pounds of sugar will be made, including firsts, seconds, and the beet sugar. In all, the factory was operated about fifty days and the whole of the sugar which was made will have been made in this time barring the usual delays incident to the use of new machinery.

The results of the season's work in general detail will be found in the following data:

The mean composition of the juice entering the diffusion battery, as obtained from samples of the fresh chips during the entire season, was—

	Per cent.
Sucrose	10.44
Glucose	2.24
Total solids	**16.40**

The analytical data disclose a juice of very even composition during the entire season, the maximum percentage of sucrose being 13.45 and the minimum 8.27; the maximum percentage of glucose 4.52 and the minimum 1.03.

The mean composition of the diffusion juice for the entire season is as follows:

	Per cent.
Sucrose	7.13
Glucose	1.45
Total solids	11.40

The mean composition of the juice from the exhausted chips during the entire season is as follows:

	Per cent.
Sucrose	1.20
Total solids	2.09

This shows rather a poor extraction, since with good shredding of the cane and good battery work the percentage of sucrose left in the juice of the chips ought not to be above 0.40 per cent.

The mean extraction on the percentage of sugar in the cane for the season was 90.2 per cent., and the mean dilution of the juice 30.58 per cent. The sucrose lost in the chips amounted to 20.4 pounds per ton of the clean chips.

From the above data much encouragement will be derived for the sorghum-sugar industry. One of the chief things accomplished by the Medicine Lodge Company was the abundant water supply which they secured.. It was the only one of the factories operated under the Department auspices in Kansas which had a sufficient supply of water. In another season, with the experience obtained during the past one, it is confidently believed that with such a location as that at Medicine Lodge, and with a crop equally good, a handsome profit can be obtained both for the farmers and the manufacturers in the production of sugar from sorghum. This, however, should not induce every one to believe that a hap-hazard investment in sorghum sugar factories, without proper study of the conditions of the problem, the character, and abundance of the water supply, the nature of the soil and climate, and the necessity of expert supervision, would produce a profitable return. Success can only be hoped for in such an industry when advantage is taken of all favorable conditions, when the machinery is erected by skilled engineers and is fully adequate to the purpose required, and when all the operations of manufacture are conducted with the greatest economy and on the strictest business principles.

OPERATIONS AT NESS CITY, MEADE, ARKALON, LIBERAL, AND MINNEOLA.

The factories above mentioned were located in the arid region of Kansas and, as it appears to me, without sufficient consideration of all the difficulties to be encountered. It is certainly true that experience has shown that sorghum is well suited to a dry climate, but there is no assurance that it will grow successfully as a sugar-producing plant in the arid regions. It is true that future experiment may develop the possibility of growing sorghum in the localities mentioned above and with a sufficient content of sugar for practical purposes of manufacture. It however betrayed a strong degree of

rashness to establish large and expensive sugar factories before having thoroughly tested the agricultural capabilities of the several locations where these factories were placed.

Sorghum has been grown in the arid region of Kansas for many years as a forage plant, but no attempts have ever been made to grow it for sugar-making purposes. The agricultural results at all the places mentioned above were most disastrous. The cane was planted without consideration of the needs of the plant, on ground insufficiently plowed and sometimes not plowed at all, and without taking any precautions to guard against the drought which is certain to prevail during the hot summer months.

On October 2 it was reported by our agent from Meade that the country was badly dried up and the cane crop ruined. At Liberal the cutting of cane was stopped on the 1st of October, after a twelve days run in which 700 tons of cane were manufactured. A small quantity of sugar was made at this place but of course nothing in a commercial way. It was also reported that there was a prospect of trouble between the farmers and the sugar company. The sugar company made a binding contract with the farmers to take all their merchantable cane and pay them $1.50 per ton; it was claimed by the farmers that the cane was ready to work into sugar by the 20th of August and that had the works been ready at that time a large percentage of the cane could have been worked into sugar and would have been merchantable. On the 2d of October the sugar company was still working at Arkalon trying to get a supply of water.

This failure to locate a sugar factory where a sufficient supply of water can be had seems somewhat strange after the publications of the Department last year in regard to this subject. In fact there seems to have been no consideration allowed to the most important factors of the problem of sugar making in the locations of these several factories. At that date, viz, October 2, no work in the manufacture of sugar had been undertaken at Arkalon and the season passed without any sugar having been made.

At Meade an attempt was made to manufacture sugar during the last week in September, and on the 2d of October they attempted to make a trial run of twenty-four hours in order to manufacture 150 tons of cane, since the company agree in accepting the bonds voted by the people at that place to erect machinery which had a capacity of this amount. After, however, making a run of some hours the factory had to shut down on account of failure in the water supply, thus failing to make the run of the 150 tons in the time specified.

The results of the work at Liberal is indicated by what has been said above, the failure of the cane crop, the failure to have the factory ready in time, and the failure to have a sufficient amount of water had it been ready, being the lamentable history. The Department made an effort through its publications to warn people of the difficulties attending the manufacture of sorghum sugar, and yet they seem to have paid little attention to these warnings, but listened rather to the representations of others, and were thus led to the voting of bonds for the erection of factories in impossible places and having no hope of success.

What is necessary in localities like Meade, Liberal, and Arkalon is first a thorough study of the agricultural problems. It is possible that by deep plowing or subsoiling sufficient moisture may be secured to carry a sorghum crop through the dry season and to mature

it for sugar-making purposes. Certainly, however, the methods of agriculture practiced during the past season, of planting on imperfectly plowed soil or in soil not plowed at all, or without any precaution to secure the deep rooting of the plants, can only end in failure unless an exceptionally wet season could be secured.

At Minneola the Adamson roasting process was tried, and on October 6, when our last report from there was received, they had been running the apparatus about eight days, working 275 tons of cane. At that time no attempt had been made to make sugar. Later reports indicate that some fraud was practiced in the sugar made later in the season by means of which the people were deceived in regard to the true capacity of the plant and the character and amount of sugar made. The theory of the roasting process is first to pass the canes through a long furnace, in which the leaves and sheathes thereof are burned off, leaving the canes cleaned and softened by the heat. The canes are then passed through an ordinary mill and the juice used for the manufacture of sugar in the ordinary way. Whether or not this principle can be made successful in practice can only be determined by further trial. In case it should be successful there is no reason why it should not be used preliminary to diffusion, thus saving the fanning and cleaning machinery now employed for that purpose with sorghum. As was the case in the other places, the factory could work very little of the time on account of a failure in the water supply.

At Ness City the story of failure which is told of the above places is to be repeated. The factory at Ness City was run in a desultory way for about ten days and several strikes of massecuite were made, but not a single pound of sugar was secured. The cane was in even worse condition than at Minneola, Meade, Arkalon, and Liberal. The factory was closed up at first and one of the townships that had voted bonds refused to pay them. The factory was then started up again and an attempt made to run long enough to legally obtain the bonds. As in the case of the other factories, the water supply was very limited and the factory could only run a part of the time on this account.

The unwise attempts to establish sugar factories and make sugar at the localities mentioned above are to be deplored, not only on account of the hardships which they impose upon the people, already poor, who voted public credit to the aid of these factories, but especially on account of the depressing influence they will have on the progress of the sorghum-sugar industry already struggling under a burden of disasters difficult to bear. When it is considered that from the very first the attempts which have been made to manufacture sugar from sorghum have been financially unsuccessful, the persistency with which the people have tried to establish this industry and the patience with which they have borne the disasters are alike remarkable. They show a strong belief which pervades a great part of our agricultural community of the necessity of the establishment of an indigenous sugar industry, and the sacrifices they are willing to make in order to secure this most desired result. The record of the above disasters does not prove that the sorghum-sugar industry is impossible, but emphasizes the fact that the conservative and unbiased conclusions of the Department of Agriculture are a far safer guide for the intending investor than the representations of irresponsible and interested parties.

PRODUCTION OF SUGAR FROM SUGAR CANE.

Although the Department did not have direct charge of any work in the production of sugar from the sugar cane in Louisiana during the past year, nevertheless three of the chemists of the Department were detailed to go to Louisiana and exercise chemical control in three of the leading factories of the State. The results of these investigations were published in Bulletins 21, 22, and 23.

Bulletin No. 21 deals particularly with the report of the experiments in the application of diffusion to the manufacture of sugar at Magnolia. The results of the work thoroughly demonstrate the practical manufacturing value of the process as applied to sugar cane. In the third run of the sugar-house, from December 1 to 8, inclusive, in which diffusion alone was worked, 1,079 tons of cane were manufactured, yielding 213.23 pounds of sugar per ton. In the fourth run, from December 9 to 22, inclusive, 1,799 tons of cane were manufactured, yielding 240.11 pounds of sugar per ton. In the fifth run, from December 23 to January 14, inclusive, 3,062 tons of cane were worked, yielding 214.45 pounds of sugar per ton. The results of the work show an immense increase in the amount of sugar yielded by this process over that obtained by the old process of milling. It is evident, from a careful comparison of the figures obtained by the average mill work, that the yield of sugar per ton of cane throughout the whole State would be increased fully 75 pounds over the present yield by the general adoption of the diffusion process. It is true that that amount of increase would not be secured over the best milling but only the average milling as practiced in Louisiana.

In Bulletin No. 22 are given the results of the factory of Shattuck & Hoffman, at Des Lignes plantation, which was operated solely by the crushing process. As a result of the work done at this station, as compared with the diffusion work, the proprietors of that factory were led to reject the mill entirely and to build and operate during the past season a diffusion battery.

Bulletin No. 23 contains the results of the season's work at Mr. Daniel Thompson's Calumet plantation, in which double crushing was practiced with saturation of the bagasse between the mills with hot water. The results obtained in this way were the highest yet noted in Louisiana with milling.

The average quantity of total sugars obtained per ton of cane was 206.85 pounds.

FOOD ADULTERATION.

Part 5 of Bulletin 13, devoted to food and food adulterants, has been published since the last Annual Report. This part treats of baking powders. The character and scope of the work are illustrated generally in the prefatory note, in which the following statements are made:

> The present part consists of an investigation of baking-powders and a résumé of our present knowledge of the subject.
>
> In these investigations we have used every endeavor to avoid error and bias. No particular powder has been favored at the expense of any other one. Our samples have been purchased in the open market, and we have had them to represent as fairly as possible the character of the goods sold.
>
> In such an investigation it is not possible to get results which will please every dealer and manufacturer, and we may therefore expect that many of our data will

be distorted or denied by interested parties. A more serious embarrassment may also confront us, and that is the use of isolated portions of this report for advertising purposes.

The public official who lends the name and authority of his office for advertising purposes has little regard for either and less for the proprieties of his position. He has, however, no longer control of the data of his analyses when they have once been published by the proper authority.

It would be well, in view of such facts, if the use of such matter for advertising purposes could be absolutely forbidden. In the present case I would like to emphasize the statement that any data or statements in the present bulletin which may be paraded by advertisers in praise of their wares would show a discrimination wholly unauthorized by the spirit and scope of this work.

In spite of the precautions mentioned in this note the work has been made a basis of many advertisements, in which it is made to appear that the Department indorses and especially commends certain brands of baking-powders in comparison with others. At the present time a scientific man can only fully and fairly express his views and state the results of his scientific investigations at the risk of seeing his name paraded in print as an indorser of almost every kind of commodity which is placed upon the market. The chemist engaged in private work and occupying no public position is at perfect liberty to allow the use of his name for such purposes, but the official chemist occupies an entirely different position. It is not so much the name of the chemist as the influence of the office which he holds which the advertiser desires to use, and the frequent occurrence of his name in advertisements and circulars does much to discredit his work among scientific men.

CHARACTER AND CONSTITUTION OF BAKING POWDERS.

By C. A. Crampton.

AERATION OF BREAD.

When bread is made by simply mixing flour with water and baking the dough, the result is a hard, tough, compact mass, "the unleavened bread" of the Scriptures. The use of yeast to "leaven" the dough is doubtless almost as old as the art of baking itself. Both kinds of bread are mentioned in Mosaic history, and its use was known in Egypt and in Greece at very early periods. Nothing has ever been found that could equal the action of yeast as a leavening agent. Carbonic-acid gas is generated by fermentation from the carbohydrates already existing in the bread, so that no foreign materials are introduced into it. The disengagement of the gas takes place slowly, so that it has its full effect in the lightening of the dough. This is an objection to its use, of course, when quick raising is desirable, and it is this slow action of yeast which has been the chief cause of the introduction of a chemical aerating agent.

The method of aeration invented by Dr. Dauglish, in England, in March, 1859, approximates more closely the action of yeast than any other method in so far as it introduces no permanent foreign substance into the bread. In his method water which has been previously charged with carbonic dioxide is used in making up the dough, the operation being performed in a closed vessel, under pressure. As soon as the dough is taken from this vessel it immediately rises, from the expansion of the gas contained in it. The method has been modified by using instead of water a weak wort, made

by mashing malt and flour, and allowing fermentation to set in. This acid liquid absorbs the gas more readily, and perhaps has some slight effect on the albuminoids, the peptonization of which constitutes an advantage of yeast-raised bread over that made by this method, in which the aeration is purely a mechanical operation. Thus the bread made by this process is somewhat tasteless, the flavors produced by fermentation within the bread being wanting. On the other hand, there is no danger of the improper fermentations which sometimes occur, and the process is especially adapted to flours which would be apt to undergo such changes when fermented. Jago* says with reference to it:

Working with flours that are weak or damp or even bordering on the verge of unsoundness, it is still possible to produce a loaf that should be wholesome and palatable, certainly superior to many sodden and sour loaves one sees made from low quality flours fermented in the ordinary manner. In thus stating that it is possible to treat flours of inferior quality by this aerating method, the author wishes specially to carefully avoid giving the impression that it is the habit of those companies which work Dauglish's method to make use of only the lower qualities of flour; he has never had any reason whatever for supposing such to be the case.

This method is in operation in all the larger cities of Great Britain, but I have no knowledge of its being used in this country.

CHEMICAL AERATING AGENTS.

The necessity of sometimes having bread preparations raised quickly for immediate baking led to the use of chemical agents for this purpose. In all of these the expansive gas is the same as where yeast is used, but instead of its being derived from the constituents of the flour it is obtained by the decomposition of a carbonate which is introduced, together with an acid constituent to act upon it, directly into the flour. When water is added to make the dough the chemicals are dissolved, the reaction occurs, and the carbonic acid is set free, while the salt resulting from the combination of the acid with the alkaline base of the carbonate remains in the bread and is eaten with it. Many suppose, and this idea is fostered by baking-powder manufacturers, that nothing remains in the bread, that everything is driven off during the baking. This is entirely erroneous, of course, and the residue necessarily left in the bread by baking-chemicals constitutes an objection to their use, and its amount and character determine to a large extent the healthfulness of the combination used. The essential elements of such a combination are, first, a carbonate or bicarbonate which contains the gas combined with an alkaline base; and, second, an acid constituent capable of uniting with the base in the carbonate and thus liberating the carbonic acid gas. For the alkaline constituent bicarbonate of soda, "baking soda," is almost exclusively employed—bicarbonate of ammonia much less. For the acid constituent, however, there is great diversity in the agents used. When the housewife mixes sour milk with baking-soda to "raise" her griddle-cakes, she makes use of the free lactic acid of the former as the acid constituent of her chemical aerating agent. When she uses "cream of tartar" or acid tartrate of potassium with soda, she uses the free tartaric acid of the former as an acid constituent, and this is the same combination that is used in one class of the baking-powders sold in the market. In fact, the entire line of such powders now sold is practically the outcome of

*Chemistry of Wheat, Flour, and Bread, and Technology of Bread-making. London. 1886.

the old-time operation of domestic chemistry, mixing "saleratus" and "cream of tartar" to aerate rolls, muffins, pancakes, and such bread preparations, which were to be baked immediately after mixing, and could not well wait for the slow operation of yeast. They consist of an acid and an alkaline constituent in about the proper proportions for combination, and in a dry state, together with various proportions of a dry, inert material, such as starch, added to prevent action between the chemicals themselves, so that the preparation may be kept indefinitely.

CONSUMPTION OF BAKING-POWDERS.

The quantity of the different chemical preparations made and consumed under the name of "baking-powders," "yeast-powders," etc., in the United States can not be stated with any degree of accuracy; neither the Statistical Division of this Department nor the Bureau of Statistics of the Treasury was able to give any information whatever upon this subject. Mr. F. N. Barrett, editor of the "American Grocer," advised me that the New York Tartar Company would probably be best able to give something of an idea, at least, of the amount produced. A letter of inquiry sent to this firm elicited the following response:

DEAR SIR: Your note of inquiry of the 22d instant was received in due course of mail. We have delayed reply thereto because of the difficulty of securing with any degree of reliability the information you seek. We believe that no one can give a correct estimate of the quantity of baking-powder annually consumed in the United States, but we are led to conclude from rather careful consideration that it amounts to between 50,000,000 and 75,000,000 pounds. Of this quantity probably two-thirds is made from cream of tartar, and the residue from phosphate and alum.

Very respectfully,

NEW YORK TARTAR COMPANY.

This would seem rather a high estimate, implying as it does an annual average consumption of a pound each by every man, woman, and child in the country. Probably few persons would suppose that it reached such a figure. Taking the price per pound at 50 cents, which is about the maximum retail price charged the consumer, together with the lower of the two figures given above, we would have $25,000,000 as the amount annually paid by consumers for this one article.

Granting that the above is somewhat of an overestimate, there can be little doubt that no other article which enters into the composition of food-stuffs, and which is not of itself a nutrient, is the subject of so great an expenditure.

The consumption of baking-powders does not seem to have become so extensive in Europe as in the United States, judging from the very small amount of attention bestowed upon the subject in works on food. Jago* makes but slight mention of their use. Doubtless the American people eat more largely of preparations of breadstuffs which are baked quickly, such as rolls, buns, etc.

In view of the large quantity of these preparations now consumed, and a lack of knowledge amongst most people concerning their composition and the chemical reactions that occur in their use, I have thought it proper to give a somewhat detailed exposition of the principles involved, and to endeavor to explain, even to the non-scientific reader, how these powders are made, and how they act.

* Op. cit.

RECENT INVESTIGATIONS.

Two important studies of the composition and character of baking-powders have been made recently, one under the direction of the Ohio Dairy and Food Commission, and the other by the Dairy Commissioner of the State of New Jersey*. Work done in this way, which has the authority and weight of official sanction, is most valuable, and I have drawn largely upon the reports above mentioned in the following pages. Many other analyses of baking powders have been made from time to time, and several extensive investigations have been carried out upon the relative merits of different kinds of powders. In fact "baking-powder literature" is quite extensive. The active competition between makers of different brands, and the methods used by them in advertising their goods, have made readers of newspapers and magazines familiar with all sorts of parti-colored statements about baking-powders in general and certain classes and brands in particular, and unfortunately such matter is not always confined to advertising columns. Most persons know comparatively little about baking-powders, and the general ignorance on the subject is taken advantage of and intensified by the manufacturers. The analyses and testimonials of eminent chemists frequently appear in such advertisements, and are often couched in terms that do little credit to the profession. I can make no use of such publications; the only material I can accept as trustworthy are the reports cited above, where the official character of the work done affords ample assurance that the investigators were influenced by unbiased and disinterested motives. It is the proper province of such bodies as State boards of health to make investigations of this kind, and results arrived at in this way are always entitled to credence, while the conclusions of scientific men, however expert they may be, are always open to doubt when they receive compensation from parties who are interested in having the results lean in their direction.

ADULTERATION.

There is no recognized standard for the composition of a baking-powder, either in this country or abroad. To prove from a legal point of view that a powder was adulterated, it would be necessary to show that it contained some substance injurious to health. Most of the treatises on food adulteration give but little attention to this class of substances, which, though not of themselves articles of food, enter into the composition of food preparations. Considerable space is devoted in such works, however, to the adulteration of bakers' chemicals. If a substance is sold as cream of tartar, for instance, which either is not cream of tartar or is sophisticated with some cheaper substance, the seller could be convicted under food-adulteration laws, but if such a fraudulent cream of tartar were incorporated into a mixture with other chemicals and the whole sold as baking-

* While the present publication was passing through the press, I have received another official publication upon this subject, constituting Bulletin No. 10 of the Laboratory of the Inland Revenue Department, Ottawa, Canada, and prepared by A. McGill, assistant to chief analyst. I regret that it appeared too late to allow of the incorporation into the present publication of any of the results and conclusions contained in it. Most of the powders examined were of Canadian manufacture, but the leading American brands were also included, and the analyses were quite complete.

powder, no conviction could be secured. In the famous "Norfolk baking-powder case" in England, which will be alluded to further on, the powder in question contained alum, which substance bakers are not allowed by law to use in bread. Yet the prosecution was not successful because it was directed against the sale of the powder, not against the bread made from it, there being no legal standard for substances sold as baking-powder in England.

CLASSIFICATION OF BAKING-POWDERS.

Baking-powders may be conveniently classified according to the nature of the acid constituent they contain. Three principal kinds may be recognized as follows:

(1) Tartrate powders, in which the acid constituent is tartaric acid in some form.

(2) Phosphate powders, in which the acid constituent is phosphoric acid.

(3) Alum powders, in which the acid constituent is furnished by the sulphuric acid contained in some form of alum salt.

All powders sold at present will come under some one of these heads, although there are many powders which are mixtures of at least two different classes.

TARTRATE POWDERS.

The form in which tartaric acid is usually furnished in this class is bitartrate of potassium or "cream of tartar." Sometimes free tartaric acid is used, but not often. Bitartrate, or acid tartrate of potassium, is made from crude argol obtained from grape juice. It contains one atom of replaceable hydrogen, which gives it the acidity that acts upon the carbonate. The reaction takes place according to the following equation:

$$\underset{\substack{\text{Potassium}\\ \text{bitartrate.}}}{\overset{188}{KHC_4H_4O_6}} + \underset{\substack{\text{Sodium}\\ \text{bicarbonate.}}}{\overset{84}{NaHCO_3}} = \underset{\substack{\text{Potassium-sodium}\\ \text{tartrate.}}}{\overset{210}{KNaC_4H_4O_6}} + \underset{\substack{\text{Carbonic}\\ \text{dioxide.}}}{\overset{44}{CO_2}} + \underset{\text{Water.}}{\overset{18}{H_2O}}$$

It will be seen that the products of the reaction are carbonic acid and double tartrate of potassium and sodium, the latter constituting the residue which remains in the bread. This salt is generally known as Rochelle salt, and is one of the component parts of seidlitz powders. A seidlitz power contains 120 grains of this salt, but the crystallized salt contains four molecules of water, and thus the actual amount of crystallized Rochelle salt formed in the baking-powder reaction is greater than the combined weight of the two salts used; that is to say, if 184 grains of bitartrate and 84 grains of bicarbonate are used in a baking there will be a residue in the dough equal to 282 grains of Rochelle salt. The directions that accompany these powders generally give two teaspoonfuls as the proper amount to use to the quart of flour; probably more is generally used. This would be at least 200 grains; deducting 20 per cent. for the starch filling we have 160 grains of the mixed bitartrate and bicarbonate, and this would form 165 grains of crystallized Rochelle salt in the loaf of bread made from the quart of flour, or 45 grains more than is contained in a seidlitz powder. The popular idea is that the chemicals used in a baking-powder mostly disappear in baking, and that the residue left is very slight. I doubt if many persons understand that when they use tar-

trate powders, which are considered to be the best class, or at least one of the best classes of such powders, they introduce into the breadstuff very nearly an equal weight of the active ingredient of seidlitz powders, and in a loaf of bread made from it they consume more than the equivalent of one such powder.

Yet the character of this residue is probably the least objectionable of any of those left by baking-powder. Rochelle salt is one of the mildest of the alkaline salts. The dose as a purgative is from ½ to 1 ounce. "Given in small and repeated doses it does not purge, but is absorbed and renders the urine alkaline." (United States Dispensatory.)

Free tartaric acid, used instead of the bitartrate of potassium, would give less residue. In this case the reaction would be as follows:

$$\underset{\substack{\text{Tartaric}\\\text{acid.}}}{\overset{150}{H_2C_4H_4O_6}} + \underset{\substack{\text{Bicarbonate}\\\text{of sodium.}}}{\overset{168}{2NaHCO_3}} = \underset{\substack{\text{Tartrate}\\\text{of sodium.}}}{\overset{230}{Na_2C_4H_4O_6.2H_2O}} + \underset{\substack{\text{Carbonic}\\\text{dioxide.}}}{\overset{88}{2CO_2}}$$

Here 150 grains of tartaric acid, with 168 grains of bicarbonate of sodium, give 230 grains of residue, or 88 grains less than the combined weight of the two ingredients. As to the character of this residue little is said in regard to the physiological properties of tartrate of sodium in the books, but probably it is essentially similar to the double tartrate. The United States Dispensatory says of it (p. 1762):

This salt, in crystals, has been recommended by M. Delioux as an agreeable purgative, almost without taste, and acting with power equal to that of the sulphate of magnesium in the dose of 10 drachms [600 grains].

I do not know why this combination should be used so seldom by baking-powder manufacturers. The free tartaric acid is more expensive than the bitartrate, but less of it is required in proportion to the amount of bicarbonate used. The former is more soluble, and this would probably be a practical objection to its use, as it is an object in baking-powders that the gas should be liberated slowly. It would perhaps be more difficult also to prevent action of the free acid upon the alkali, so that the powder would be more likely to deteriorate in keeping. Only one sample among those I examined was found to have been made with the free acid.

One obstacle formerly encountered in the manufacture of bitartrate powders was the difficulty of obtaining the bitartrate pure. It contained from 5 to 15 per cent. of tartrate of lime incident to the method of manufacture. This brought a large quantity of inert material into the powder and lowered its efficiency. Bitartrate can now be had 98 per cent. pure, quoted and guarantied as such in the markets, so that there is no excuse for manufacturers to use the impure salt, which can properly be considered adulterated.

PHOSPHATE POWDERS.

The salt commonly used to furnish the phosphoric acid in this class is acid phosphate of lime, sometimes called superphosphate. The pure salt is monocalcic phosphate, $CaH_4(PO_4)_2$. It is made by the action of sulphuric acid upon ground bone, the result being an impure monocalcic phosphate with calcium sulphate. This mixture is sold as a fertilizer, as superphosphate. The salt is, of course, more or less purified for use in baking-powders, but the sulphate of lime is very difficult to get rid of entirely, and most phosphate

powders contain considerable amounts of this impurity. The reaction which occurs when a phosphate powder is dissolved, that is the action of bicarbonate of soda upon monocalcic phosphate, is not well established, and perhaps varies somewhat with conditions. The following equation probably represents it fairly well:

$$\underset{\text{Monocalcic phosphate.}}{\overset{234}{CaH_4(PO_4)_2}} + \underset{\text{Bicarbonate of soda.}}{\overset{168}{2NaHCO_3}} = \underset{\text{Monohydrogen calcic phosphate.}}{\overset{136}{CaHPO_4}} + \underset{\text{Disodic phosphate.}}{\overset{142}{Na_2HPO_4}} + \underset{\text{Carbonic dioxide.}}{\overset{88}{2CO_2}} + \underset{\text{Water.}}{\overset{36}{2H_2O}}$$

Two hundred and thirty-four grains of monocalcic phosphate combined with 168 grains of bicarbonate of soda give 136 grains of monohydrogen calcic phosphate, and 142 grains of disodic phosphate. But crystallized sodic phosphate contains twelve molecules of water, and has a molecular weight of 358. So the total amount of residue from 402 grains of the powder would be 494 grains, of which 136 grains is phosphate of lime and the rest phosphate of soda. So we see that here also the quantity of chemicals introduced into the dough is fully equal to the amount of the baking-powder used, including filling. As to the nature of this residue in phosphate powders, it would seem to be about as unobjectionable as in the tartrates. Phosphate of soda is "mildly purgative in doses of from 1 to 2 ounces" (480–960 grains) according to the United States Dispensatory. Phosphates of calcium have the general physiological effect which is ascribed to all forms of phosphoric acid, but which does not seem to be well understood.

Phosphates are administered therapeutically in some cases of defective nutrition, and especially in scrofula, rickets, phthisis, etc. On account of their being an essential constituent of animal tissues there would seem to be some ground for a preference over other forms of powders. The makers of phosphate powders claim that the use of such powders restores the phosphoric acid present in the whole grain of wheat, which is largely removed in the bran by milling processes. This claim would have more weight if there were not ample sources of phosphoric acid in other forms of food, and if the quantity introduced by a baking-powder were not much greater than is required to make up the loss in the bran, and greater than is required by the system, unless in those cases where its therapeutic use is indicated, as in some of the conditions of malnutrition given above.

Acid phosphate of soda is said to have been used in former years as a constituent of baking-powders, but appears to have been entirely superseded by the lime salt.

ALUM POWDERS.

In this class the carbonic acid is set free from the bicarbonate by the substitution of sulphuric acid, which combines with the sodium. The sulphuric acid is furnished by some one of the general class of salts known as alums, which are composed of a double sulphate of aluminium and an alkali metal. The alum is precipitated as hydrate, while that portion of the sulphuric acid which was combined with it goes to displace the carbonic acid in the bicarbonate. The alkali sulphate of the double salt remains unchanged.

The alum of commerce is either *potash alum*, $K_2Al_2(SO_4)_4.24H_2O$, or *ammonia alum* $(NH_4)_2Al_2(SO_4)_4.24H_2O$, the one or the other predominating according to the relative cheapness of the alkali salt it

contains. At the present time nothing but ammonia alum is met with, but at previous periods potash alum was the salt sold exclusively as "alum." Both salts are alike in general appearance and can not be distinguished apart by cursory examination.

Potash alum may be made directly from some minerals, such as the "alum stone" mined in Italy, which contain all the constituents combined. Ammonia alum, however, as well as most potash alum, is made by the combination of the constituents obtained from different sources. The sulphate of alumina is obtained by the action of sulphuric acid upon pure clays, and the sulphate of ammonia from the residue of gas-works. Solutions of the two salts in proper proportions are mixed and the double salt obtained by evaporation and crystallization.

Crystallized potash or ammonia alum contains twenty-four molecules of water, nearly one-half of its weight. Part of this water is lost at as low a heat as 60° C., and it is driven off entirely, though slowly, at 100° C. "Burnt alum" is simply alum deprived of its water of crystallization, which is generally driven off at about 200° C. Ammonia alum decomposes at 205° C.; potash alum at a somewhat higher temperature. Burnt alum is somewhat hygroscopic, but dissolves more slowly in water than the crystallized salt.

I have been unable to ascertain in what condition the alum is used for compounding baking-powders. Burnt alum would seem to be the form best adapted for this purpose on account of its slow solubility. Professor Cornwall says this is the form* used, but does not state how he obtained the information; and he states further that "crystallized alums may be used in connection with burnt alum to secure at first a more rapid escape of carbonic-acid gas." It is probable that the amount of drying given the alum used differs with different manufacturers, but it is not likely that the water of crystallization is entirely driven off.

The following equation shows the reaction taking place in a baking-powder made with burnt ammonia alum:

$$\underset{\substack{\text{Sulphate of aluminium}\\ \text{and ammonia, or}\\ \text{"burnt alum."}}}{\overset{475}{(NH_4)_2Al_2(SO_4)_4}} + \underset{\substack{\text{Bicarbonate of}\\ \text{soda.}}}{\overset{504}{6NaHCO_3}} = \underset{\substack{\text{Hydrate of alumin-}\\ \text{ium.}}}{\overset{157}{Al_2(OH)_6}} +$$

$$\underset{\substack{\text{Sulphate of}\\ \text{soda.}}}{\overset{426}{3Na_2SO_4}} + \underset{\substack{\text{Sulphate of am-}\\ \text{monia.}}}{\overset{132}{(NH_4)_2SO_4}} + \underset{\text{Carbonic dioxide.}}{\overset{264}{6CO_2}}$$

If potash alum were used the reaction would be precisely the same with the substitution of potassium for ammonia wherever it occurs in the equation, sulphate of potash being formed instead of sulphate of ammonia.

A study of the equation will show that 475 grains of burnt alum with 504 grains of bicarbonate will produce 264 grains of carbonic acid and leave a residue consisting of 426 grains of sulphate of soda, 132 grains of sulphate of ammonia, and 157 grains of hydrate of aluminium, the last named being a precipitate insoluble in water. Sulphate of soda crystallizes with ten molecules of water, so that the total weight of residue from the 979 grains of mixed chemicals would be 1,255 grains. If a hydrated alum is used in the powder,

* Report of the Dairy Commissioner of New Jersey, 1888, p. 70.

the proportion of residue to powder would of course be less, and the proportion of gas evolved would also be less. The character of the residue is seen to be more complex than is the case with any of the classes previously discussed, and deserves special attention. The sulphate of soda is similar to other alkali salts in its physiological action. Sulphate of ammonia is not used therapeutically, but probably has an action similar to that of other ammonia salts, such as the chloride. Professor Cornwall,* in his report, speaks as follows concerning this point:

It is possible, however, that too little attention has been paid to the presence of ammonium salts in the residues from ammonia alum powders. * * * We do know, however, that ammonia salts, in general, are much more irritating and stimulating in their action than the corresponding soda salts, or even than the potash salts. For instance, Stillé and Maisch, speaking of ammonium bromide, state that it has a more acrid taste and is more irritating than potassium bromide. Its unpleasant taste and irritating qualities render it less convenient for administration than the bromide of potassium.

We all know how mild a substance is chloride of sodium (common table salt); but of ammonium chloride Stillé and Maisch write: "The direct effects of doses of five to twenty grains of this salt, repeated at intervals of several hours, are a sense of oppression, warmth, and uneasiness in the stomach, some fullness in the head. If it is used for many days together in full doses, it disturbs the digestion, coats the tongue, and impairs the appetite." We have already seen how active a drug carbonate of ammonia is, and while, in the absence of proof, it would be rash to assert that sulphate of ammonia in five-grain doses is certainly injurious, yet there is abundant ground for further investigating its effect before asserting that it is milder in its effects than Rochelle salt. It may be that this question of the presence of ammonium salts in any considerable quantities in the residues of baking-powders deserves more attention than it has hitherto received.

It would seem from the above that there would be considerable difference between the physiological effects of potash and ammonia alums themselves. Yet the medical authorities make no such distinction. Ammonia alum is officinal in the British Pharmacopœia, and while the United States Pharmacopœia specifies potash alum, the particular form met with in trade is entirely determined by the comparative cheapness of manufacture.

The question of the relative harmfulness of these different salts in the residues of baking-powders is really one for the physiologist or hygienist to decide, not the chemist. Physiological experiments alone can decide them positively.

The consideration of the residue of hydrate of aluminium will be taken up later on.

POWDERS CONTAINING MORE THAN ONE ACID INGREDIENT.

As might be expected, some powders are met with which have been made up with various proportions of different acid ingredients, and which belong therefore to more than one of the above-mentioned classes. Professor Cornwall speaks as follows concerning some of these mixed powders:

The makers of alum baking-powders sometimes add tartaric acid or bitartrate to their powders, either with or without the addition of acid phosphate of lime. This is doubtless done with the best intentions, either to secure a more rapid escape of carbonic-acid gas at the outset or otherwise improve the powder. We have found such additions in the case of several of our samples, but the presence of tartaric acid or tartrates in alum powders is very objectionable. If added in sufficient quantity to otherwise pure alum powders, they prevent the precipitation of the insoluble hydrate of aluminium entirely when the powder is boiled with water, and they may render much of the alumina soluble in water even after the bread is

*Op. cit., p. 77.

baked. Without doubt it would then be readily soluble in the digestive organs, producing there the effects due to alum or any other soluble aluminium compound. With one of our samples we found that the simple water solution seemed to contain as much alumina as a nitric-acid solution. In neither of these solutions could any of the alumina be thrown down by a slight excess of ammonia water, although it was readily precipitated from the solution first rendered alkaline with caustic soda, then slightly acidified with acetic acid and boiled with excess of phosphate of soda.

A case in which the character of the powder appears to be improved by such mixing, however, is furnished by the

ALUM AND PHOSPHATE POWDERS.

This combination seems to be a favorite one with manufacturers. In fact there are now comparatively few "straight" alum powders in the market, most of the cheaper grades being made of mixtures in various proportions of the alum with acid phosphate of lime. The reaction it is intended to obtain is probably the following:

$$\underset{\text{Ammonia alum.}}{\overset{475}{(NH_4)_2Al_2(SO_4)_4}} + \underset{\text{Acid phosphate of lime.}}{\overset{234}{CaH_4(PO_4)_2}} + \underset{\text{Bicarbonate of soda.}}{\overset{336}{4NaHCO_3}} = \underset{\text{Phosphate of aluminium.}}{\overset{245}{Al_2(PO_4)_2}} +$$

$$\underset{\text{Sulphate of lime.}}{\overset{136}{CaSO_4}} + \underset{\text{Sulphate of aluminium.}}{\overset{132}{(NH_4)_2SO_4}} + \underset{\text{Sulphate of soda.}}{\overset{284}{2Na_2SO_4}} + \underset{\text{Carbonic-dioxide.}}{\overset{176}{4CO_2}} + \underset{\text{Water.}}{\overset{72}{4H_2O}}$$

If this equation be compared with the one representing the reaction in a powder made with alum alone, on page 170, it will be seen that in the former the alum goes into the residue as phosphate instead of hydrate, and the insoluble sulphate of lime takes the place of one molecule of sulphate of soda. Otherwise the reactions are similar. This reaction will only take place, of course, when the different ingredients are mixed in just the proper proportions to produce it. A number of variations may be produced by changing the relative proportions of the different ingredients.

THE "ALUM QUESTION."

The literature upon the subject of the use of alum in baking-powders, and upon the question as to its injurious effect upon the health of those who consume the bread made from it, is already quite extensive, and if quoted entire would fill a fair-sized volume. For the benefit of those who may desire to make an exhaustive study of it, I will make reference to all of the articles bearing upon the subject that have come under my observation, as follows:

Alum in baking-powder, by Prof. G. E. Patrick.—*Scientific American Supplement, No.* 185,'7, p. 2940.

Report of proceedings in the Norfolk baking-powder case (first trial).—*Analyst*, 4, p. 231.

Norfolk baking-powder case (second trial).—*Ibid.*, 5, p. 21.

Editorial comment on the case.—*Ibid.*, 5, pp. 13 and 34.

On the action of alum in bread making, by J. West Knights.—*Ibid.*, 5, p. 67.

Cereals and the products and accessories of flour and bread foods, by E. G. Love, Ph. D.—*Second Annual Report State Board of Health of New York*, 1882, p. 567.

On the solubility of alumina residues from baking-powders, by Lucius Pitkin.—*Journal American Chemical Society*, 9, p. 27.

Experiments upon alum baking-powders and the effects upon digestion of the residues left therefrom in bread, by Prof. J. W. Mallet.—*Chemical News*, 58, pp. 276 and 284.

As I have previously indicated, the matter of the physiological effect of the residues left by baking powders is not properly a chemical problem. On account of the interest and importance attached to it, however, it would seem necessary to give here somewhat of a résumé of the subject without attempting to arrive at a definite conclusion, or to settle, arbitrarily, the question as to whether the sale of certain forms of powders should be prohibited.

For a proper understanding of the alum question it is necessary to explain that the use of alum in bread-making is prohibited in countries having food-adulteration laws, such as England and France. This is partly on account of its injurious effect upon the system, but principally because of its peculiar action, not yet well understood, in improving the color and appearance of the bread to which it has been added, so that a flour of inferior grade, or even partially spoiled, may be used to make bread which will look as well, to all appearances, as bread made from much better grades.

Blyth* speaks as follows of this use of alum in bread:

> Alum is added to bad or slightly damaged flour by both the miller and the baker. Its action, according to Liebig, is to render insoluble gluten which has been made soluble by acetic or lactic acids developed in damp flour, and it hence stops the undue conversion of starch into dextrine or sugar. The influence of alum on health, in the small quantities in which it is usually added to bread, is very problematical, and rests upon theory more than observation. But notwithstanding the obscurity as to its action on the economy there can be no difference of opinion that it is a serious adulteration and not to be permitted.

Allen† says:

> Alum, or an equivalent preparation containing aluminium, is by far the most common mineral adulterant of bread, though its use has greatly decreased of late years. Its action in increasing the whiteness and apparent quality of inferior flour is unquestionable, though the cause of its influence has not been clearly ascertained. Whether there be sufficient foundation for the statements made respecting the injurious effects of alumed bread on the system is still an open question.

The following is from Hassall:‡

> With reference to the use of alum, Dr. Dauglish has written: "Its effect on the system is that of a topical astringent on the surface of the alimentary canal, producing constipation and deranging the process of absorption. But its action in neutralizing the efficacy of the digestive solvents is by far the most important and unquestionable. The very purpose for which it is used by the baker is the prevention of those early stages of solution which spoil the color and lightness of the bread whilst it is being prepared, and which it does most effectually; but it does more than needed, for, whilst it prevents solution at a time that is not desirable, it also continues its effects when taken into the stomach, and the consequence is that a large portion of the gluten and other valuable constituents of the flour are never properly dissolved, but pass through the alimentary canal without affording any nourishment whatever."

The manufacturers of alum baking-powders, however, claim that the hydrate of aluminium which is left in the residue is insoluble in the digestive juices, and therefore does not produce the effect which is attributed to the soluble forms of alum. Aluminium hydrate is insoluble in water, but readily soluble in dilute acids, especially when freshly precipitated. When heated it gradually loses its water of hydration, but does not part with it entirely short of a very high heat. When completely dehydrated it is insoluble even in dilute acid. It never reaches this condition in baked bread, in which the temperature probably never, in the center of the loaf at least, exceeds 100° C.

---

* Foods, Composition and Analysis, p. 168.
† Commercial Organic Analysis, 1, p. 371.
‡ Food, its Adulterations, and the Methods for their Detection, p. 344.

Phosphate of aluminium is somewhat less soluble in dilute acids than the hydrate. In the Norfolk case an effort was made by the prosecution to show that the soluble phosphates contained in the ash of flour combined with the alum to form phosphate of aluminium, thus rendering them insoluble in the digestive juices and depriving the flour of an important constituent, and considerable evidence was offered by the defense to show that this was not the case. Whether the addition to alum powders of sufficient acid phosphate to combine with the aluminium present as phosphate was the result of this discussion or not I can not say, but it is certain that most of the alum powders now met with are made in this way, so that if such a prosecution were to occur to-day the relative position of the parties would be reversed. It would be to the interest of the alum-powder makers to show that phosphate of aluminium is insoluble in the alimentary canal. The solubility of these compounds in water or dilute acids is, of course, a question readily answered by any chemist, but their solubility in the complex and various alimentary fluids, and under the conditions of natural digestion in the human body, is quite another matter.

As might be expected, the testimony which has been published upon this point is of the most conflicting character. Professor Patrick, experimenting upon cats, found little or no solution of hydrate of aluminium. Professor Pitkin, experimenting with gastric juice obtained from a dog, found some solution, although he used phosphoric acid in his powder. Professor Mallet, using an artificial gastric juice, found some solution to occur, even with the phosphate, and considerably more with the hydrate. It is not difficult to find reasons for such disagreement in results, for, besides the various character of the solvents used and the different conditions prevailing, it is easy to see that even if the hydrate and phosphate of aluminium were themselves entirely insoluble, more or less aluminium would escape the reaction, either from imperfect mixing of the powder in the dough or from improper proportioning of the different ingredients in the powder itself, so that it would go into the residue in the form of the original salt. With powders specially prepared, on the other hand, and very carefully mixed, and kneaded up thoroughly with the dough, it might be possible to find but a very little dissolved in the digestive fluids under certain conditions, even though the salts formed were slightly soluble in such fluids.

From the various evidence that has been produced on both sides of the question, I think the following conclusions may be safely drawn:

(1) That form of alum powder in which sufficient phosphate is added to combine with all the aluminium present is a better form, and less apt to bring alum into the system than where alum alone is used.

(2) It must be expected that small quantities, at least, of alum will be absorbed by the digestive fluids where any form of powder containing it is used.

(3) Whether the absorption of small quantities of alum into the human system would be productive of serious effects is still an open question, and one that careful physiological experiment alone can decide.

As the experiments made by Professor Mallet are the most recent on this subject, I quote here his conclusions. I may say that most of those based upon purely chemical work I can indorse, having confirmed many in my own work, but I think the evidence furnished

by his physiological work is hardly sufficient to justify his conclusion as to the harmfulness of such powders.

GENERAL SUMMARY OF THE CONCLUSIONS REACHED.*

The main points which seem to be established by the experiments under discussion are, briefly stated, the following:

(*a*) The greater part of the alum baking-powders in the American market are made with alum, the acid phosphate of calcium, bicarbonate of sodium, and starch.

(*b*) These powders, as found in retail trade, give off very different proportions of carbonic-acid gas, and therefore require to be used in different proportion with the same quantity of flour, some of the inferior powders in largely increased amount to produce the requisite porosity in bread.

(*c*) In these powders there is generally present an excess of the alkaline ingredient, but this excess varies in amount, and there is sometimes found on the contrary an excess of acid material.

(*d*) On moistening with water these powders, even when containing an excess of alkaline material, yield small quantities of aluminium and calcium in a soluble condition.

(*e*) As a consequence of the common employment of calcium acid phosphate along with alum in the manufacture of baking-powders, these, after use in bread-making, leave at any rate most of their aluminium in the form of phosphate. When alum alone is used the phosphate is replaced by hydroxide.

(*f*) The temperature to which the interior of bread is exposed in baking does not exceed 212° F.

(*g*) At the temperature of 212° F. neither the "water of combination" of aluminium hydroxide nor the whole of the associated water of either this or the phosphate is removed in baking bread containing these substances as residues from baking-powder.

(*h*) In doses not very greatly exceeding such quantities as may be derived from bread as commonly used, aluminium hydroxide and phosphate produce (or produced in experiments upon myself) an inhibitory effect upon gastric digestion.

(*i*) This effect is probably a consequence of the fact that a part of the aluminium unites with the acid of the gastric juice and is taken up into solution, while at the same time the remainder of the aluminium hydroxide or phosphate throws down in insoluble form the organic substance constituting the peptic ferment.

(*k*) Partial precipitation in insoluble form of some of the organic matter of food may probably also be brought about by the presence of the aluminium compounds in question.

(*l*) From the general nature of the results obtained, the conclusion may fairly be deduced that not only alum itself, but the residues which its use in baking-powder leaves in bread, can not be viewed as harmless, but must be ranked as objectionable, and should be avoided when the object aimed at is the production of wholesome bread.

COMPARISON OF THE DIFFERENT CLASSES OF POWDERS IN RESPECT TO THEIR RELATIVE AERATING STRENGTH AND THE AMOUNT OF RESIDUE LEFT BY EACH.

The following comparison of the different powders described may prove interesting. It is assumed, of course, that the ingredients are combined in exactly the proper proportions, and that all the chemicals used are of full purity and strength:

Powders.	Carbonic-acid gas.	Total residue in per cent. of the weight of chemicals used.
	Per cent.	*Per cent.*
Tartrate	16	104
Phosphate	22	123
Alum	27	128
Alum and phosphate	17	111

*Chemical News, 58, 276; also published in pamphlet form.

From this it will be seen that a tartrate powder, theoretically, gives the lowest percentage of carbonic-acid gas in proportion to the weight of chemicals used in its composition, together with the least weight of residue; and a straight alum powder gives the highest proportion of gas, with the greatest weight of residue. It is assumed that burnt alum is used in both the alum and the alum-and-phosphate powders. The residues are calculated to hydrated salts in all cases. No account is made of inert "filling," as that would be the same in each case. It should of course be remembered that in the above calculation the *total weight* of residue is reckoned in each case without regard to solubility or relative effect upon the system of the various salts formed. This has been sufficiently discussed under the different classes.

CARBONATE OF AMMONIA.

This salt is used to some extent as an ingredient in baking-powders. It is also often used alone by bakers as a chemical aerating agent. It does not necessarily require an acid to set free its gases, being volatilized without decomposition simply on heating. The commercial salt, familiar to everybody as "smelling-salts," or *sal volatile*, is obtained by subliming a mixture of two parts of chalk and one part of sal ammoniac or sulphate of ammonia. The salt is then resublimed with the addition of some water, and a white semi-transparent mass is obtained, which has a strong ammoniacal smell, and a pungent, caustic taste. It has the composition $N_3H_{11}C_2O_5$, and consists of a compound of hydrogen ammonium carbonate with ammonium carbamate, $H(NH_4)CO_3 + NH_4CO_2NH_2$. "When heated the salt is wholly dissipated, without charring; if the aqueous solution is heated to near 47° C. it begins to lose carbonic-acid gas, and at 88° it begins to give off vapor of ammonia." (United States Pharmacopœia.) The question of the propriety of the use of this salt in baking does not seem to have received a great deal of attention, and opinions differ. Hassall* says of it:

> * * * Of these, by far the best is carbonate of ammonia; this is a volatile salt, and its great advantage is that it is entirely or almost entirely dissipated by the heat employed in the preparation of the bread; and thus the necessary effect is produced without risk of injurious results ensuing.

This would doubtless hold good if it were quite certain that the salt is *entirely* driven off by the baking of the bread, for it is a very active therapeutic agent, acting as a corrosive poison when taken in sufficient amount. The ordinary dose is five grains. Doubtless in the small quantities used in baking-powders, and in the presence of other chemicals, there is little danger of its being left in the bread undecomposed, but the advisability of its use alone as an aerating agent is open to grave doubt.

Of the samples analyzed in the Chemical Division the aeration strength found is expressed by the following numbers:

TARTRATE POWDERS.	Per cent.
Royal Baking-Powder	12.74
Dr. Price's Cream Baking-Powder	11.13
Cleveland's Superior Baking-Powder	12.58
"Sea Foam" (Gantz) Baking-Powder	8.03
Hecker's Perfect Baking-Powder	9.29
Gilbert S. Graves's Imperial Baking-Powder	7.28
Thurber's Best Baking-Powder	10.26
Sterling Baking-Powder	9.53
Our Best Baking-Powder, made by the Purity Chemical Works, Philadelphia, Pa	4.98

* Page 345.

PHOSPHATE POWDERS.

Wheat Baking-Powder, made by Martin Kalbfleisch's Sons, New York	3.79
Rumford Yeast-Powder	12.86
Horsford's Self-Raising Bread Preparation	13.56

ALUM POWDERS.

Vienna Baking-Powder	6.41
Metropolitan Baking-Powder	8.10
Cottage Baking-Powder	6.62

MIXED POWDERS.

Dooley's Baking-Powder	9.62
Miles's Premium Baking-Powder	3.56

ALUM AND PHOSPHATE POWDERS.

Henkel's Baking-Powder	7.74
Mason's Yeast-Powder	9.96
Dixon Yeast-Powder	10.37
Patapsco Baking-Powder	7.58
Patapsco Baking-Powder	6.70
Patapsco Baking-Powder	8.42
Silver Spoon Baking-Powder	7.33
Windsor Baking-Powder	9.36
Davis's O. K. Baking-Powder	8.10
Brunswick Baking-Powder	9.81
Atlantic and Pacific Baking-Powder	7.91
Silver King Baking-Powder	4.99
Eureka Baking-Powder	7.62
Silver Star Baking-Powder	7.61
Purity Baking-Powder	7.13

FILLING.

It is evident that of several powders made up of the same materials, the one which contains the smallest proportion of inert matter or filling, other things being equal, will have the best carbonic-acid efficiency or "strength." On the other hand, if the amount used is too small for the proper preservation of the sample, it will deteriorate rapidly, and perhaps will show less strength after keeping a short time than any other powders with a somewhat larger amount of filling. It becomes a question, therefore, as to the minimum limit of the amount of filling that is consistent with good keeping qualities. Professor Prescott* says on this point:

> From 13 to 18 per cent. of starch is not too much for the permanence of a cream of tartar baking-powder, but filling beyond 20 per cent. must be held an unquestionable dilution.

In my samples the average per cent. of starch in the bitartrate powders was 14.04; the highest was 24.57 per cent., and the lowest 5.32 per cent. The latter sample evidently did not contain enough, for it had a much lower carbonic-acid strength than most of those that had more filling. The bitartrate powder containing the maximum of filling, No. 5527, contained also the lowest per cent. of available carbonic acid. The powders made up with free tartaric acid contained much more filling, this being doubtless necessitated by the more hygroscopic character of the free acid. They contain, respectively, 40.05 and 45.63 per cent. of starch, and 9.53 and 4.98 per cent.

* Organic Analyses, 500.

of available carbonic acid. Of the phosphate powders No. 5508 contains rather a large amount of filling, 26.41 per cent., while No. 5506 contains none at all, evidently to its detriment, as previously noted. Even the acid part of No. 5509 contains 20.81 per cent. of starch, although it is kept separate from the alkali. It is in the alum and the alum-and-phosphate powders, however, that the highest percentages of filling are found. The average of all is 40.76 per cent. of starch, the maximum 52.29 per cent., the minimum 31.54 per cent. Here we find the cause for the low percentages of available carbonic acid in these powders, which should, theoretically, afford a higher carbonic-acid strength than any of the other classes. Whether a large amount of filling is more necessary where alum is used to prevent deterioration, whether it is added simply as a diluent, so that the amount of alum taken into the stomach will be less apt to produce an injurious effect, or whether it is added to cheapen the powder, I can not say. The first hypothesis seems the most probable, especially if the alum is used with but a small proportion of its water of crystallization driven off. If the second is true, the object is not obtained, of course, for the more filling used the greater the quantity of powder required to produce the same aerating effect, and as for the third, alum and soda are about as cheap as starch.

It must be remembered that the percentages of starch given in the tables represent *anhydrous* starch.

"DOMESTIC BAKING-POWDERS."

It may be asked, can not the consumer make up his own baking-powders? The difficulties in the way of doing this may be enumerated as follows:

(1) The chemicals in the market, as purchased by the consumer, may not be pure, or of full strength, so that when combined in proper proportions they do not give good results.

(2) The proper proportions to use, and the necessity of thorough mixing to secure good results, would not be well understood by any one who was not a chemist.

(3) In order to prevent the action of the ingredients upon one another, and to preserve the strength of the powder unimpaired as long as possible, the manufacturer *dries* all his chemicals before mixing them, so as to drive off most of the adhering moisture. Baking-soda can not be dried much, as it loses its carbonic acid, and consequently its efficiency, at very low temperatures. The starch, however, containing as it does from 10 to 18 per cent. of moisture, can be thoroughly dried at 100° to 105° C., and its efficiency as a filling material greatly increased. The cream of tartar can also be thoroughly dried. This operation of drying chemicals at a temperature below that at which decomposition would occur seems rather too elaborate an operation for the kitchen.

These difficulties are more apparent than real, however. In answer to the first, it may be said that the bitartrate is the only chemical which is likely to be adulterated, and as there is no difficulty nowadays in obtaining a pure article in the wholesale market, it only requires the proper enforcement of adulteration laws to oblige the retailer to furnish a good article. The second objection may be met by furnishing the public simple formulæ for compounding such powders; and the third, which is doubtless the most serious, I believe can be overcome by using a larger proportion of filling, without drying the chemicals.

In the present days of cooking-schools, when so much interest is taken in the preparation of food, and in all branches of the culinary art, it may not be amiss to devote a little space to the discussion of this subject, although it is not, perhaps, strictly within the scope of the present investigation.

With a view of determining the possibility of making up baking-powders from a simple formula that could be used in the household, and also to see what strength of powder could be obtained by lessening the quantity of filling used, I compounded a number of powders from commercial cream of tartar and soda, using different proportions of starch, and determined the per cent. of carbonic acid, both total and available, in each. The chemicals used were dried before mixing, and the latter operation very thoroughly performed.

Formula No. 1, *containing* 20 *per cent. starch filling.*

Cream of tartar .... ounces..	8
Baking-soda .... do....	4
Corn starch .... do....	3
Total carbonic acid .... per cent..	13.39
Available carbonic acid .... do....	11.96

Formula No. 2, *containing about* 15 *per cent. starch filling.*

Cream of tartar .... ounces..	8
Baking-soda .... do....	4
Corn starch .... do....	2
Total carbonic acid .... per cent..	14.60
Available carbonic acid .... do....	12.89

Formula No. 3, *containing* 10 *per cent. starch filling.*

Cream of tartar .... ounces..	6
Baking-soda .... do....	3
Corn starch .... do....	1
Total carbonic acid .... per cent..	15.10
Available carbonic acid .... do....	13.70

From the above it will be seen that most excellent results were obtained with these powders, made up by simple formulæ. The powder containing the least percentage of starch, formula No. 3, gave 13.70 per cent. of available carbonic acid, nearly 1 per cent. more than the highest result obtained in any of the commercial samples. To be sure these powders were freshly made, and would doubtless deteriorate on keeping, those with the lowest amount of starch perhaps more rapidly than the others, as most of the commercial samples containing less than 10 per cent. of starch show low percentages of available carbonic acid, No. 5505 being an exception. But these prepared samples establish very completely the point I desired to make, that baking-powders can be readily made up by simple formulæ that will compare favorably with the best samples obtainable in the market.

These samples, however, were all made with *well-dried* ingredients, as they would be by a manufacturer. The next question is, whether a powder could be made which would keep without serious deterio-

ration, without drying the chemicals. To this end I used a larger proportion of starch according to the following formula:

Formula No. 4, made without drying the ingredients, containing 25 per cent. starch filling.

Cream of tartar	ounces	8
Baking-soda	do	4
Corn starch	do	4
Total carbonic acid	per cent	12.63
Available carbonic acid	do	10.91

This gives a fairly good amount of available gas, considerably higher than the average of the commercial samples. Estimations of the available carbonic acid in the same sample after it had stood over two months in the laboratory showed absolutely no loss in strength. I had it tried in a practical way by several persons in the Department who used it in their kitchens, and reported excellent results, finding it fully as efficient in all respects as the powder they were accustomed to buy. The consumer can pay full retail price for the ingredients and still make it up for about half the price at which a good powder is sold, and if he makes sure of the quality of his cream of tartar he will have an article of which the purity is assured, and which has not lost in strength by being kept in stock an indefinite length of time by the retailer. I can see no reason why all housekeepers should not make their own baking-powder.

REGULATION OF THE SALE OF BAKING-POWDERS.

The best plan for the regulation by law of the sale of baking-powders in the present condition of our knowledge of their effect upon the system would seem to be to require the manufacturer to use a label giving approximately the composition, or analysis, of the powder sold. This is recommended by Professor Cornwall, and it appears to offer the best solution of the whole problem. The testimony that has been adduced is hardly sufficient to justify the prohibition of the sale of the cheaper kinds of powders as being injurious to health, but if they were required to be sold with a label giving their true composition it would soon lead to investigations upon this point. This is in harmony, also, with modern ideas in regard to legal regulation of the sale of food-stuffs, the tendency nowadays being to allow the sale of cheap substitutes for any article of food so long as they are not actually injurious to health, but to make all possible provision to insure that the purchaser should know exactly what he is getting, and that the substitute shall not be palmed off on him as the genuine article. In the case of baking-powders it is manifestly unjust to the public to allow the sale of a first-class tartrate powder and an alum powder as the same article, and it is equally unjust to the manufacturer of the higher-priced article. The nature of the substance is such that the purchaser has no means of ascertaining by any simple or easy means the character of the article he buys, to say nothing of its relative quality. Such a regulation should meet with the approbation of all concerned in the manufacture of baking-powders. The manufacturers of high-grade powders, such as tartrate or phosphate powders, would certainly not object to it, and it would ultimately be to the advantage also of the cheaper sorts, such as alum powders, provided they could succeed in proving that such powders produced little or no injury to the health of the consumer.

Ample analogy and precedent for such regulation are furnished

by the laws for the sale of fertilizers which are in operation in most of the States. Although these substances are used for widely different purposes, the conditions that require the legal supervision of their sale are quite similar in many respects. A substance sold as a fertilizer must have its composition, in so far as is necessary for its valuation for such a purpose, plainly stated on the bag in which it is sold, because the purchaser has no means of ascertaining this value by any ordinary or simple test. Otherwise the manufacturer could easily impose upon him by selling him a powdered substance which resembled a fertilizer in general appearance, but contained no constituent of any value whatever for fertilizing purposes. The purchaser of a baking-powder receives a white powder which may contain various substances more or less valuable for the desired purpose, or of no value whatever, or perhaps even injurious to the health.

The housewife surely deserves protection against swindling as much as the farmer, and she has no better means for ascertaining the strength and quality of the baking-powder she buys than the latter has for learning the strength of his fertilizer. The verity and accuracy of the analysis stated on the label should be insured, as in the case of the fertilizer, by its being performed by sworn analysts. If such a regulation were enforced, people would soon inform themselves of the respective merits of different varieties, and the further requirement of a certain standard of strength, as suggested by Professor Cornwall, would probably be unnecessary, as they would learn to interpret the analysis, and a powder made up with 50 per cent. of starch, for instance, would have to be sold cheaper than one made with 10 per cent., or not sold at all.

INFLUENCE OF FOOD, ANIMAL IDIOSYNCRACY, AND BREED ON THE COMPOSITION OF BUTTER.

One of the fundamental principles of dairying is regard for the influence which the care of the animal, supervision of the milking, separation of the cream, ripening of the cream, churning and washing, have on the quality of butter for table use. These processes also, together with the method of packing, have a notable influence upon the preservation of the butter in a sweet state. The discussion of the above problems, however, is a thing for the practical dairyman rather than the chemist. The chemical composition of butter fat, as influenced by the character of food received by the animal, the race of the animal, and the peculiarities of the animal, has hitherto been little studied from a chemical point of view. To the latter subject I propose to devote the following paper.

Late in February, this year, I received a letter from Prof. H. H. Harrington, chemist of the Experimental Station of Texas, accompanied by two samples of butter which he asked me to examine. The following extract from Professor Harrington's letter will indicate the motive which led him to send samples:

Some work in our laboratory indicates that volatile acids from the cotton-seed butter are much lower than has been generally supposed. I send two samples of butter, one from cotton-seed feed and the other from feed containing no cotton-seed. If you can do me the favor of analyzing this butter, I shall send more samples from the same cows on the same feed. We hope in the near future to follow up these analyses with complete analyses of butter from different feeds, feeding two cows on cotton-seed and then changing them to other feed.

The two samples of butter received from Mr. Harrington were entered as follows: Butter from cotton-seed No. 6316; butter from other feed, No. 6317.

The samples sent by Mr. Harrington were small and a complete analysis could not be made; but the results obtained on the small samples sent are of such interest that I will communicate them at the present time and call attention to the peculiarities noticed.

Results of analyses.

[Degrees Centigrade.]

	Volatile acids $\frac{N}{10}$ BaO_2H_2 for 5 grams.	Iodine absorbed.	Melting point.	Reduction of silver by Bechi.
	Cc.	*Per cent.*	°	
6316	21 00	33.40	45	Distinct.
6317	28.50	31.89	34.2	None.

The most remarkable points connected with the above analyses are as follows:

(1) The low percentage of volatile acids in butter from cotton-seed.

(2) The phenomenally high melting point of the butter from cotton-seed.

(3) The persistence of the reducing agent of the butter from cotton-seed as indicated by its action upon nitrate of silver.

The melting point of the butter, as will be seen, is higher than that of pure lard. The particular point to be noticed in this matter is that in butter designed for consumption in southern countries, or produced in southern countries, the mixture of cotton-seed with the feed of cows will tend to raise the melting point of the butter and render it more suitable for consumption in hot climates.

The persistence of the reducing agent is also a matter of interest. It has passed, in the samples examined, through the digestive organism of the cow and has re-appeared in the butter with almost undiminished activity. The selective action of the digestive organs on the different glycerides contained in the food of the animal is also a matter of importance. It would be expected *a priori* that the butter from a cow fed largely on cotton-seed oil would contain more olein and have a lower melting point than if ordinary food were used. On the contrary it is seen that either the more solid glycerides have been absorbed during the process of digestion or that the olein has undergone some distinct change in the digestive organism by which it has assimilated the qualities of the other glycerides.

From an analytical point of view the results are of great importance, since they show that a butter derived from a cow fed on cotton-seed meal or one excreting a fat of unusual quality might be condemned as adulterated when judged alone by the amount of volatile acids present. Since cotton-seed meal is destined to be a cattle food of great importance, especially in the southern part of the United States, this is a fact of the greatest interest to analysts.

The observation of Mayer, soon to be mentioned, that the specific gravity of butter fat varies with its content of volatile acids, I have also verified in some cases by the determination of the specific gravity of samples of butter fat taken from the milk of the same cows kept on the same food, but taken the following day after the samples mentioned.

The specific gravity for the cotton meal fed sample was .8929 at 99°; the specific gravity for the ordinary fed sample was .8991 at 99°.

Professor Mayer's experiments were made on a single cow of a North Holland breed. From time to time during the progress of the experiments the original food was used in order to see what effect the period of lactation would produce. The cow was fed for twelve days on each separate ration before the samples were taken. After two days more another set of samples was taken, and then the food changed for a new experiment.

In the butter fat the melting and solidifying points were taken and the volatile acids determined according to the method of Reichert. The specific gravity was also determined by the Westphal method at 100°.

The rations of the cow were composed of the following materials:

Ration No. 1. 15 kilograms meadow hay and 2 kilograms linseed cake.

Ration No. 2. Siloed grass *ad libitum*, and 2 kilograms linseed cake.

Ration No. 3. 20 kilograms beets, 8 kilograms hay, and 2 kilograms linseed cake.

Ration No. 4. Pasture grass *ad libitum*.

Ration No. 5. Chopped clover with 14 per cent. of other grasses *ad libitum*.

The highest melting point observed (viz, 40.5) was from ration No. 1, and the lowest (viz, 32.5) from ration No. 5. The highest volatile acids were produced by No. 3, and required 33.5 cubic centimeters $\frac{N}{10}$ alkali. The lowest volatile acids, viz, 20 cubic centimeters, were observed with ration No. 2.

The results of my analyses were obtained on the first samples of butter sent by Mr. Harrington, and were published in Agricultural Science for April 1, 1889, pp. 80 *et seq.* Not fully satisfied with the result of a single determination, I asked Professor Harrington to send me other samples of butter, which he did on two subsequent occasions. The analyses of the two last sets of samples sent did not fully bear out the results obtained in the first set. This led me to believe that perhaps the influence of the animal was not fully allowed for in Professor Harrington's samples. The last two sets of samples were analyzed with the following results:

No. 6347, sample from cow fed on corn meal and wheat bran only.

Nos. 6348, 6349, and 6350 from cows fed on 2 pounds cotton-seed meal, 4 pounds cotton-seed, and 16 pounds corn and wheat bran.

No. 6374, from cow having no cotton-seed in food.

Nos. 6375, 6376, and 6378, from cows fed solely on cotton-seed meal.

The analytical data obtained are as follows:

	Specific gravity at 100° C.	Volatile acid $\frac{N}{10}$ alkali.	Melting point.
	°	*Cc.*	°
6347	....	24.70	35.10
6348	*.9063	27.50	40.60
6349	.9009	27.70	40.30
6350	.9009	25.30	40.30
6374	.8967	19.95	36.90
6375	.8989	27.20	34.45
6376	.8962	25.80	36.60
6378	.8989	25.40	36.23

*This number is probably too high.

The above data are very perplexing. The conclusions derived from the first set of samples are supported solely from the fact that the cows fed on cotton-seed meal gave butters which, with one exception, had a higher melting point than ordinary butter. The phenomenally low percentage of volatile acids in 6374 would indicate that the cow furnishing this sample was the same as that furnishing the low volatile acids in the first set of samples. An inquiry directed to Professor Harrington to elucidate this point, however, has not yet been answered, Mr. Harrington replying that he has not had time to inform me on the subject.

Another supposition is that in some way the numbers of the samples may have been changed in the analysis, but this is scarcely probable. The importance of a more careful study of this subject led me to institute some feeding experiments of my own in order to unravel, if possible, the mysteries of the preceding analyses. I accordingly obtained authority from the Secretary of Agriculture to arrange for certain feeding experiments with Professor Alvord, of the Maryland Agricultural Experiment Station. Three cows were selected for these experiments, described by Professor Alvord as follows:

No. 1. Full-bred Jersey.
No. 2. Full-bred Ayrshire.
No. 3. Cross-bred Jersey and Ayrshire.

These cows were kept on ordinary pasturage for ten days, and then the milk from each of the cows for three days was taken for the experiments. All the milk was subjected to the same conditions. It was set in earthen bowls in a refrigerator, at 45° to 50° Fah., and skimmed after twelve hours. The cream was mixed and kept at 55° to 60° Fah. until the fourth day after the beginning of the milkings. The cream was then ripened in a room, at 60° Fah. temperature, for twenty-four hours. After cooling to 62° Fah., the cream was churned, the temperature rising from 62° Fah., at the beginning of the churning, to 65° at its close. The time required for each churning was twenty minutes. The three days on which the milk was saved were damp, hot days, very unfavorable for making good butter. In all cases the butter was thoroughly washed in cool well-water, made into rolls, and put in glass jars. One-half of each sample of the first lot was salted at the rate of two-thirds of an ounce of salt to 1 pound of butter.

After the conclusion of the first set of experiments the cows were gradually changed to a ration of cotton-seed meal, using the commercial variety, such as is used for fertilizing purposes, as no unextracted cotton-seed meal could be obtained at this season of the year. The ration of cotton-seed meal was gradually increased, the cows finally being given all they would eat of it. The following are the facts as to the second lots:

The feeding of cotton-seed meal was commenced on the 25th of July, giving but 1 pound at a feed at first, but constantly increasing the quantity. The milk saved and used for the second lots of butter was that of the 2d, 3d, and 4th of August. Below is given a table showing the quantity of meal consumed; milk, cream, and butter produced from each cow, and time of churning:

Lot.	Breed.	Cotton-seed meal consumed on August 1, 2, and 3.	Milk product used for the butter August 2, 3, and 4.	Cream from the milk stated churned.	Butter made from the stated cream August 6.	Time of churning for each lot.	Temperature of cream at starting churn.
		Lbs.	*Lbs. oz.*	*Lbs. oz.*	*Lbs. oz.*	*Min.*	°
1	Jersey	28	32 15	16 8	2 05	13	62
2	Ayrshire	32	37 00	9 12	1 12	22	62
3	Cross-bred Jersey and Ayrshire	29	32 04	9 0	1 07	14	63

During this trial the cows were turned into a small lot with very short pasturage, for exercise and access to running water.

They were fed only the cotton-seed meal and consumed the quantity stated. At close of trial the Jersey and cross-bred cows were beginning to refuse the meal. The Ayrshire continued to eat all offered and probably could have been fed 12 pounds a day—but I was afraid to give her over 11 pounds a day and did that only twice. (She later kept on at 8 and 10 pounds per day, while the others fell to 1 and 2 pounds.)

The analytical data obtained on these samples of butter are found in the following table:

DESCRIPTION OF SAMPLES.

6467, unsalted butter from pure Jersey cow on pasture, no feed.
6468, unsalted butter from pure Ayrshire cow on pasture, no feed.
6469, unsalted butter from cross-bred Jersey and Ayrshire on pasture, no feed.
6470, salted butter, same as 6467.
6471, salted butter, same as 6468.
6472, salted butter, same as 6469.
6478, butter from pure Jersey cow fed on cotton-seed meal.
6479, butter from pure Ayrshire cow fed on cotton-seed meal.
6480, butter from cross-bred Jersey and Ayrshire fed on cotton-seed meal.

In addition to the above samples I have also included two samples of creamery butter from a large creamery at Attica, Kans.

Eight thousand pounds of milk are received daily at this creamery, all of which comes from native cows feeding on native prairie grass, with the exception of a few Holstein cows kept by one person.

6409, butter from Attica Creamery, made May 20, 1889.
6473, butter from Attica Creamery, made July 20, 1889.

Table of analyses.

[Degrees centigrade.]

Serial No.	Melting point.	Iodine absorbed.	Volatile acids $\frac{N}{10}$ BaO_2H_2 for 5 grams.	Specific gravity.	Bechi's reaction.	Milliau's reaction.	Fatty acids.	
							Crystallizing point.	Iodine absorption.
	°	*Per cent.*	*C. c.*				°	*Per cent.*
6467	34.9	37.7	22.8	.9010	None.	None.	38.95	38.69
6468	36.3	41.1	22.5	.9005	None.	None.	39.80	42.50
6469	35.2	38.0	22.1	.9019	None.	None.	38.55	39.20
6470	35.3	37.9	22.3	....	....	....	....	....
6471	35.6	40.7	22.5	....	....	....	....	....
6472	35.2	38.2	22.3	....	....	....	....	....
6478	38.4	34.9	21.4	.9016	Marked.	Marked.	41.25	37.96
6479	40.0	36.8	20.8	.9012	Marked.	Marked.	43.30	38.72
6480	38.3	35.2	21.1	.9011	Marked.	Marked.	41.45	37.63
6409	33.3	....	28.1	.9001	....	....	....	....
6473	34.4	29.8	29.3	.9021	Trace.	Trace.	39.60	31.26

The study of the data in the above table reveals many points of interest. In general the data corroborate the results of the first study of the samples sent by Professor Harrington. The melting points of the butters from cows fed on cotton-seed meal are markedly higher than from the other samples. There is also a markedly diminished content of volatile acids in these butters and a lower iodine absorption power. The latter character is unlike the Harrington sample. Another characteristic phenomenon noticed in the first samples of butter is also here repeated, namely, the persistence of the reducing agent which is present in cotton-seed oil in the butter derived from animals fed thereon. The physiological importance of this phenomenon will be mentioned in another place. The most curious results, however, of these experiments is found in the increase in the butter of the glycerides having a high melting point; in other words, the glycerides of the palmitic and stearic series. While further experiment may be necessary to show that there is a uniform diminution of volatile acids in butters from cows fed on cotton-seed meal, the fact is now most clearly established that the melting point of such butters is uniformly higher. In regard to the absorption of iodine by the butters from cotton-seed fed cows, the results obtained above are somewhat at variance with those secured by Ladd,* who states that butter from cows fed on linseed meal contained 3.5 per cent. more olein than those samples which were obtained from cows fed on bran. This conclusion of Ladd's, however, may not be the true one, since linseed oil has an iodine absorption of about 155 per cent., and this high co-efficient may have had some influence upon the butter as regards iodine absorption. It is possible, therefore, that some of the linoleic glyceride, which has so high an iodine absorbing power, may have found its way into the butter, thus increasing its iodine absorption.

Another important characteristic of the butters examined is seen in their abnormally low content of volatile acids. If we compare the samples from the Maryland station with those from Kansas, we have a very characteristic contrast between abnormal pure butter and normal pure butter. The two samples from Kansas show a percentage of volatile acids which is not unusually met with in samples of pure butter. On the other hand, the samples from the Maryland station show an abnormally low content of volatile acids. This percentage of volatile acids is indeed so low that these butters would be condemned as spurious if we relied upon the volatile acid test alone. It does not seem so strange in the light of these facts that Allen should have found abnormal Danish butters which, nevertheless, from their history, were certainly genuine.

In so far as the breed of the animal is concerned in the above experiments, it does not seem to have greatly influenced the composition of the butter. The low content of volatile acids may therefore be attributed either to the pasturage or to the peculiarity of the animals themselves, or to the period of lactation.† It would hardly seem probable, however, that three animals taken at random should have

* Report of New York Experiment Station for 1888, page 91.

† The time at which each of the cows in the above experiments commenced giving milk is as follows: Jersey cow, February 3, 1889; Ayrshire cow, March 23, 1889; cross-bred Jersey Ayrshire, April 15, 1889. The period of lactation therefore was not far enough advanced, the experiments having been made in July, 1889, to have accounted for the abnormal character of the butter obtained.

exhibited in almost the same degree the abnormal qualities indicated in the composition of the butters above.

The physiological questions which are suggested by the above study are of the utmost consequence. In a paper entitled "Note on the action of digestive fluids on oil," published in The Medical News of July 28, 1888, I called attention to the remarkable influence exerted on a large quantity of oil in the human digestive organs. A pint of oil, presumably sweet oil, but more likely cotton oil, was administered to the patient for the relief of an obstruction in the gall duct. This oil in passing through the digestive organs was completely decomposed mostly into fatty acid with some soap, forming an emulsion in the alimentary canal, and being voided in the form of rounded masses of considerable consistence were mistaken by the patient for gall stones. This action of the digestive liquids was entirely unexpected and seems to show that the commonly accepted notion that the fats are acted upon in the digestive organs by being emulsified and thus absorbed into the circulatory fluids is an erroneous one.

It is the common supposition that the fats have for a physiological function the maintenance of the animal heat of the body and the nutrition and supply of the fatty portions thereof.

The experiments in feeding cows on cotton-seed meal would seem to indicate that the natural glycerides contained in cotton-seed meal do not appear in the butter of the cows fed thereon. If the cotton-seed oil in the food should pass unchanged into the butter, we might, it is true, have a lowering of the volatile acids, but this would be accompanied by a great increase in the iodine absorption and a marked lowering in the melting point. It is quite certain that the glycerides of butter which yield on saponification volatile acids are not derived from similar glycerides in the food of the animal. It may also be quite true that none of the glycerides in the butter of the cow is derived from the fat of the food of the animal. It is more than likely that the fat of milk is a direct product of digestion and is formed conjointly from the carbohydrates and the albuminoids in the cow's food. We need not, therefore, be perplexed any longer at the presence of so small a portion of stearine and so large a proportion of the butyric series of the glycerides in the fat of milk.

From the evidence already at hand, I think we would be justified in saying that practically all the fats in milk are products of digestion and none of them results of simple translation through the digestive organs or fats already present in food. On the other hand we have undoubted evidence of the translation of other substances directly from the food of the cow to the butter fat, as is shown in the presence of the aldehyd in cotton oil, which reduces silver, in the butter of cows fed on these substances. Among other studies on the influence of the food on the composition of butter I might cite the paper of Ladd, already noted, and also one by C. J. von Lookeren, published in the Milch Zeitung, No. 3, 1889, page 47, and the paper of Mayer, published in Die Landwirtschaftlichen Versuchs-Stationen," vol. 35, page 261. These studies are of such practical interest that it is my intention to continue them during the coming year on an extended series of feeding experiments, in which I hope to interest experimenters in different parts of the country.

COMPOSITION OF BUTTERS SENT BY PROF. G. E. MORROW FROM THE CHICAGO DAIRY SHOW, DECEMBER, 1889.

These butters presumably represent first-class articles and analyses are interesting in showing what the composition of pure butter should be. In the following table will be found the analysis of each sample. The means may be taken to represent fairly well the composition of a first-class article of butter.

[Degrees centigrade.]

No. of sample.	In the filtered fat. Refraction index at 30°; water at same temperature equals 1.3321.	Specific gravity compared with water at boiling point.	Melting point.	Iodine absorbed.	Volatile acids per 5 grams BaO_2H_2, in cc. BaO_2H_2.	In the butter. Moisture.	Salt and ash.	Curd.
			°	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
*750 †6583	1.4579	.90120	31.8	36.9	25.5	8.69	4.58	0.86
*751 †6582	1.4569	.90173	32.4	32.4	27.7	10.47	3.52	1.13
*752 †6581	1.4571	.90026	32.2	32.1	27.9	9.52	3.40	1.01
*762 †6586	1.4565	.90294	32.8	31.9	Not determined	8.87	2.13	0.74
*764 †6587	1.4573	.90059	32.9	38.4	25.2	8.85	3.35	0.49
*765 †6589	1.4570	.89982	32.2	32.5	27.4	9.82	2.60	0.89
*766 †6588	1.4571	.90069	32.5	35.4	27.5	9.78	2.06	0.72
*767 †6585	1.4565	.90091	32.8	32.1	27.2	11.86	1.77	1.20
*770 †6584	1.4572	.90023	32.8	34.1	28.6	8.95	3.11	1.04
Means.	1.4569	.90093	32.5	34.0	27.1	9.65	3.00	0.84

* Chicago number. † Serial number.

COMPOSITION OF LARDS SENT BY HON. W. J. IVES, DAIRY COMMISSIONER OF MINNESOTA.

Five samples of lard were sent to the Department for examination by the Hon. W. J. Ives, dairy commissioner of Minnesota. From the examination which they received in Minnesota it was thought that they might be adulterated with cotton oil. There was not a sufficient quantity of the samples for making a complete examination, but the analyses were extended as far as the amount of material would permit. The analytical data obtained are found in the following table:

[Degrees centigrade.]

No. of sample.	In the filtered fat. Refraction index at 30°; water at same temperature equals 1.3321.	Specific gravity compared with water at boiling point.	Melting point.	Iodine absorbed.	Rise of temperature with H_2SO_4.
			°	*Per cent.*	°
6590	1,4621	.89472	39.2	58.3	39.0
6591	1,4624	.89643	38.2	60.7	40.0
6592	1,4618	.89488	38.8	59.5	35.5
6593	1,4618	.89500	38.8	59.9	35.0
6594	1,4618	.89567	38.2	59.0	35.0
6595	1,4622	.89533	40.2	60.4	38.0

The lards were also examined with nitrate of silver but no reduction of the silver could be secured which would indicate the presence of any notable portion of cotton oil. The quantity of the material at my disposal did not permit a complete examination of the samples for color reaction with sulphuric and nitric acids, but in so far as the test was applied no certain indication of cotton oil was detected.

The microscopical examination of the crystallized fats showed some indication of the presence of beef-fat crystals, but the proof was not definite. In all respects the samples deported themselves like pure lard and they could not be condemned as spurious without more extensive and thorough examination.

THE FOOD VALUE OF SORGHUM SEED.

For many years the value of sorghum seed as food for animals has been recognized, and it has been extensively used, especially for feeding swine. The chief objection to its use has been on the supposition that it contained tannin, or some bitter principle, which would prove injurious to stock. A careful examination of sorghum seed has failed to discover the presence of tannin, and the only possible injurious principle which it can contain is the coloring matter of the glumes. A careful examination of this coloring matter has been made and its composition determined. It consists of 33.5 per cent. of carbon, 6.6 per cent. of hydrogen, 7.2 per cent. of nitrogen, and 52.5 per cent. of oxygen. Any possible ill effects of this coloring matter, when seed is used for food, can be removed by the removal of the glumes, which would not be a difficult mechanical process. Compared with maize and oats, the seed itself is shown to be of fair quality, equal in food value to either of the other substances named. Analyses were made of a great many different varieties of seed, but the chief difference in the varieties is shown in the percentage of coloring matter rather than in the composition of the seed itself. If sorghum should be raised for seed alone, those varieties producing a pure white seed, like the White Mammoth, should be preferred to those producing highly colored seeds, like the Early Amber and most of the varieties of Chinese cane. The percentage of moisture in sorghum seed is about 10, the actual percentage found being 9.59 as a mean of 48 analyses. The percentage of albuminoids was found to be 11.71; of fat, 3.35; of substances soluble in ether, 0.50 per cent.; the soluble carbohydrates, 3.37 per cent.; the percentage of ash, 1.70; of indigestible fiber, 1.89 per cent.; the percentage of starch and insoluble digestible carbohydrates was 68.03. These analyses will compare favorably, in regard to the food value, with those of maize. The above analyses were based on the seeds from which the glumes had been removed.

The value of sorghum seed, as a food for man and other animals, is found to be fully equal to maize and oats and but little inferior to wheat. When fed, excepting to poultry, the seed should be either ground or boiled, otherwise much of it will pass the digestive organs untouched.

ANALYSES OF WHEAT AND BARLEY.

Four samples of wheat from Weiser, Idaho, sent by V. D. Hannah, accompanied by the following letter:

WEISER, IDAHO, *February* 14, 1889.

DEAR SIR: Inclosed find samples of four varieties of wheat, which I think it hard to beat. Last season was the worst ever seen since the settlement of Idaho.

We are always glad to try anything new. This bearded sample came from you, and we raised last season at the rate of 70 bushels per acre. I prize it very highly.

Very respectfully,

V. D. HANNAH.

COMMISSIONER OF AGRICULTURE.

The samples were analyzed with the following results:

Serial No. 6450, short, heavily bearded head.
Serial No. 6451, short head without beard.
Serial No. 6452, short, rugged, but unbearded head.
Serial No. 6453, long, unbearded head.

	Serial No.				Average.
	6450.	6451.	6452.	6453.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	14.55	12.59	14.04	12.85	13.51
Ash	3.00	2.30	2.58	2.31	2.55
Fat	2.45	2.25	2.00	2.25	2.24
Fiber	1.20	1.40	1.48	1.16	1.31
Albuminoids	14.35	11.20	12.51	12.34	12.60
Carbohydrates (difference)	64.45	70.26	63.39	69.09	67.79
	100.00	100.00	100.00	100.00	100.00
Weight of 100 grains ... Grams	3.160	3.360	3.405	3.000	3.231

These samples show a very high percentage of albuminoids in 6450, a rather low percentage in 6451, and a mean percentage in the other two samples.

From W. H. P. Trudgeon, Purcell, Ind. T., a sample of wheat which had the following composition:

Serial No. 6385.

	Per cent.
Water	13.27
Ash	1.88
Fat	2.31
Crude fiber	1.90
Albuminoids	13.12
Carbohydrates (by difference)	67.52

From D. H. Talbot, Sioux City, Iowa, a sample of barley, which had the following composition:

	Per cent.
Water	12.03
Ash	2.19
Fat	2.40
Crude fiber	1.58
Albuminoids	15.93
Carbohydrates (by difference)	65.87

From T. J. Wrampelmeier, San Diego. Cal., a sample of wheat, which, on examination, gave the following results:

	Per cent.
Water	11.56
Ash	1.90
Fat	2.42
Crude fiber	1.76
Albuminoids	11.03
Carbohydrates (by difference)	71.33

REPORT OF THE MICROSCOPIST.

SIR: I have the honor to submit herewith my eighteenth annual report.

The work of this division for the past year has been largely in the line of original investigations relating to the microscopy of food-stuffs, including the condiments of commerce. Micro-photographs and colored drawings with the camera lucida have been made, which represent the characteristics of certain pure food products and of the adulterants used in them.

Tea has received special attention; methods are pointed out which show how foreign leaves may be detected in a sample of adulterated tea. This paper is highly illustrated with micro-photographs and colored drawings which accompany my report.

Olive oil has also been the subject of investigation, and in this connection fully fifteen hundred experiments have been made relating to the color reactions of the food and medicinal fats and oils, with a view to discover new and simple methods of detecting fraudulent imitations. In this line of research I have made several discoveries which promise to be of great value in the future.

The microscopy of various textile fibers has also received consideration.

The continued demand for my report on the edible mushrooms of the United States would indicate that this subject is one of considerable interest to the public. A chart is in process of preparation which will show how to discriminate between poisonous and nutritious varieties.

About one thousand letters have been answered on various subjects pertinent to the work of the division during the year. Agreeably to an order from the Secretary of Agriculture a special exhibit was prepared for the Paris Exposition, relating to food adulterations and comprising certain instruments of precision, of my invention, relating to and facilitating the labor of the microscopist, for which a silver medal was awarded.

Respectfully submitted.

THOMAS TAYLOR,
Microscopist.

HON. J. M. RUSK,
Secretary of Agriculture.

TEA AND ITS ADULTERATIONS.

ORIGINAL MICROSCOPIC INVESTIGATIONS.

Notwithstanding the numerous microscopic investigations which have been made during the last twenty years, relating to the external and internal structure of the tea leaf, with a view of being able to distinguish it from the leaves of other plants, there seems to be a necessity for further investigation in this direction, judging from my recent observations in this line of research.

In making preliminary examinations of tea-leaf dissections, I discovered peculiarly formed, isolated cells (polarizing bodies) seemingly having no connection whatever with the general cell-structure of the leaf. On looking up the various writers on food adulterations, I found the following notice of these peculiar cells termed "idioblasts" in Blythe's Analysis of Foods:

> Idioblasts are long, tough, tenacious, branched cells, which seem to act as pillars or beams, keeping the two layers of the leaf apart; they do not occur in any other leaf with which the tea-leaf is likely to be confused, so that their presence would indicate tea, their absence would point to foreign leaves. A very convenient method of detecting "idioblasts" is given by Moeller: Small fragments of the leaf are warmed in a very strong solution of caustic potash and then placed under the thin covering glass and pressed firmly.

They must be viewed under suitable powers of the microscope. Botanists have given various names to the "idioblasts," such as "scleroblasts," "scelerenchyma," and "stone-cells" (so called after the stony bodies found in the flesh and stalk of many pears which are composed of them). Their function is not positively known. Du Bary, Sachs, Bessey, and others, give full information in their respective botanical works regarding their presence in many plants and their supposed use. The general structure of the tea-leaf presents to the ordinary observer nothing of peculiar importance, but on closer inspection with even the low powers of the miscroscope an experienced microscopist will easily detect these cells, especially by means of polarized light, in the transverse and longitudinal sections of the midrib of the leaf. They are also found scattered in great numbers, irregularly, throughout the body of the leaf. The stone-cells of the Camellia japonica, which belongs to the tea family, differ slightly from those found in the leaf of the tea-plant. The leaves of some species of camellia, of which it is said by Carpenter there are many, are said to have been used as adulterants of tea by the Chinese merchants about twenty years ago. The leaves of the species japonica are very thick and fleshy as compared with the tea-leaf proper, and therefore may be distinguished from the latter.

The presence of stone-cells in the leaf of the tea-plant, and their absence, according to Blythe, in all other plant leaves not of the tea family used as adulterants of tea, if correct, is an important factor to begin with. My experience, in this respect, agrees with that of Blythe. I have examined the following leaves used as adulterants of tea, viz, willow, sloe, beech, Paraguay tea, ash, black currant, Camellia japonica, two species of hawthorn (one the common English hawthorn) and raspberry, but find in them no trace of these peculiar cells, except in the case of the camellia, which belongs to the tea family. I find, however, that many of the leaves above mentioned contain a class of crystals not observed in the tea-leaf, viz, crystals of oxalate of lime, while the willow and others contain the starry forms known as "raphides," which are also found in the tea-leaf.

Raphides are aggregations of acicular or needle-like crystals common to many plant leaves said to be used in tea adulterations. Blythe has alluded to them.

While it is well known that only the small or young tea-leaves are generally employed in the commercial product, the structural characteristics of the larger leaves are more easily differentiated and are quite suggestive of what to expect in the more delicate forms. Students should begin with the larger leaves. For these investigations leaves from the living plant are required, which I have readily obtained, in all stages of growth, from the propagating grounds of this Department.

"The mesophyl or parenchyma of the tea-leaf contains two kinds of cells, the one being a very regular single or double row, filled with chlorophyl, just beneath the upper epidermal layer, whilst a spongy parenchyma containing large spaces occupies the rest of the leaf thickness." (Blythe.) Having ascertained the order and form of cell arrangement in the mature leaf, the investigator proceeds with the knowledge thus acquired to the more delicate tea-leaves of commerce. The first difficulty met with in this experiment arises from the changed condition of the leaf, the result of manipulation. The leaf in its natural state is firm and without curl, while as manufactured it is dry, fragile, and much of it in the form of powder. The leaves most favorable for examination, however, are those compactly rolled. With a little experience and patient perseverance the artificial conditions and attended difficulties are easily overcome. The simple process of infusion will remove much of the difficulty. It will be found that many of the rolled leaves are entire; these should be separated from fragmentary leaves, but all fragments should be examined, and it is a good plan to assort the different forms, placing each lot of a similar kind by itself. Many of the fragments will exhibit the edges of the leaf entire. Secure a sufficient number of them by means of any suitable cement, on slips of glass 3 by 1 inch, and examine the indented edges (serrations), using low powers of the microscope. Make drawings of them and compare with the genuine tea-leaf. Transverse and longitudinal sections of the leaves should be made and mounted in the usual way for observation and comparison under the microscope and for purposes of photography. Portions of the epidermis may be easily removed by macerating or scraping the leaf, and when taken from the green leaf are better for photography than specimens obtained from the leaf by the use of chemicals. In the subjoined plates will be found some of the marked characteristics of the tea-leaf as well as of leaves used as adulterants of tea. It is hoped that by means of these illustrations those engaged in this line of work will be able to acquire a better knowledge of the simplest methods of determining what is tea and what are adulterations of tea.

HOW TO DETECT STONE-CELLS IN THE TEA-LEAF.

I have tested Moeller's method, but find it deficient in one particular. He says: "Treat the leaves with a warm and strong solution of caustic potash and mount with a thin covering glass and press firmly." The student will experience great difficulty in discovering stone-cells by this method. Modify the method as follows: Boil the tea or other suspected leaves in a solution of strong caustic potash or soda for three minutes, allow the solution to cool, remove a

leaf or portion of leaf, as the case may be, by means of forceps, placing the specimen on a slip of glass 3 by 1 inch with a second slip of glass of the same dimensions over and in contact with the first slip, thus covering the specimen; press firmly, using slight friction, so that the leaf will appear as a mere stain between the glass slips. This method, while it disintegrates the cell tissue, does not impair the outline of the stone-cells, of which numerous groupings may be observed. Leaf hairs are frequently distinctive, and not being injured by the caustic potash solution, are often observed in great profusion, indicating sometimes the species of plant to which the leaf belongs, and thus assisting in some cases in distinguishing tea-leaves from those leaves used as adulterants. In order to become familiar with the general appearance of the entire cell arrangement of the tea-leaf, it will be necessary to devote considerable time to the work, familiarizing one's self with the many forms observed under both high and low powers of the microscope, noting not only the cell forms but also the relative size of the cells. This will be found particularly valuable in making examinations of what is sold for tea-dust, which may contain very little tea and consist mostly of raspberry leaves or other worthless substance purposely reduced to a fine powder to make detection difficult. But when it is considered that a particle of this tea-dust, so called, measuring only the one-hundredth of an inch in diameter, if magnified three hundred times will appear under the microscope 3 inches in diameter, it will be seen that the cell-structure may be easily observed and its character ascertained.

The early investigators of adulterated food supplies have enumerated may substances found in tea, but it is acknowledged that many adulterants formerly used are now discarded. The truth is, that many of the adulterants were so easily detected and punishment of the offender so certainly followed that the mixer was forced either to abandon the practice or so to modify it by the use of harmless substances that the question now is resolved simply into that of the consideration of relative cost. That is to say, the principal question which interests the consumer, and especially the poorer classes, relates to economy and not to the poisonous character of the adulterant. If a person pay $1 for a pound of so-called tea containing half a pound of black currant leaves costing only 2 cents, it is evident that the purchaser has paid for half a pound of tea nearly $1. The poor are generally the greatest sufferers in this way, as they deal generally on credit and frequently with irresponsible persons. Most of the teas shipped from Japan to the United States are now artificially colored. Formerly this was not the case. In the early years of the trade, say from 1859 to 1869, the manipulation of Japan teas by the exporter was confined to a simple refiring, which was necessary in order to cure the leaf sufficiently to enable it to endure transportation through the tropics and to retain its qualities while in store. This process alone required large establishments and a considerable plant, as well as important outlays for labor and fuel. But the leaf was improved by the expenditure, and Japan teas were then shipped in their natural condition and honestly called "uncolored." About 1870, however, consumers began to call for higher color than any natural process would furnish, and although this demand was long resisted by the shippers in Japan, and at some loss to themselves, yet ultimately it prevailed, and for some years past artificial coloring has been the rule, so that Japan teas, which are naturally of a

blackish-green color, are now made to resemble the bluish-gray or grayish-blue teas shipped from China as "green teas."

The materials used to produce these unnatural shades are not very pernicious, it is said, being nothing worse as a general rule than indago and gypsum, but they certainly add nothing to the value of the tea-leaves for drinking purposes, while they do add considerably to their cost. There is nothing to be said in favor of the practice, except that dealers in America prefer teas of that description. Their doing so is probably explained by the fact that in teas so colored coarse leaves may pass without detection, and this no doubt is the cause of the gradual deterioration of the quality of Japan teas exported to America during recent years. The adulteration will probably continue as long as consumers buy, in America, teas only in accordance with the appearance of the leaf, regardless of its infusive qualities, and as long as the simple secret of making the infusion is so little understood in our country. To the Japanese, who value tea for its fragrance and delicacy and who are careful to draw these qualities from the leaf by the use of pure water and nice vessels, the article is an abomination, and they naturally conclude that the quality of the leaf which is subjected to such treatment is not important. According to a late United States consular report, the American demand for the uncolored teas known as "basket-fired" has latterly increased; and it would be as advantageous to the consumer in the United States as it would be gratifying to most shippers in Japan, if this inclination to return to the honest, uncolored teas, were to become general, for it would certainly result in greater discrimination in the picking and preparation of the leaf in Japan, and would afford consumers better teas at lower prices, would restrict the supply to good teas only, and would revive the favor which Japan teas formerly enjoyed in the American market, as compared with the highly colored teas of China.

In accordance with your request, I read an abstract of my paper on tea and its adulterations before the Society of American Microscopists, in Buffalo, N. Y., in August, 1889. The secretary of the society informs me that the paper will be published in the society's volume of proceedings for 1889.

PLATE 1.

FIG. 1 represents the epidermal layer of the lower surface of the tea-leaf, showing the "breathing pores" or stomata in the intercellular spaces. The green portion represents the palisade cells charged with chlorophyl.

FIG. 2. Loose cells containing chlorophyl. (A) A stone-cell or idioblast as seen by polarized light, under high powers of the microscope; found in the fleshy part of the leaf.

PLATE 2.

FIG. 3 represents the internal structure of a portion of the leaf showing stone-cells, loose cells, vascular bundles, raphides, and oil globules, under polarized light.

FIG. 4. The epidermal layer, upper surface of the tea-leaf, in which I have not observed stomata.

PLATE 3.

Five stone-cells, as seen by polarized light in a longitudinal section of the midrib of a tea-leaf. This section was only one-quarter of an inch in length, in which all these cells were observed. The stone-cells of the tea-leaf generally average about one-hundredth of an inch in length and are polarizing bodies. If subjected to the action of caustic potash their polarizing property is greatly impaired.

PLATE 4.

FIG. 5 represents a cross-section of a leaf of Camellia japonica showing the position of the stone-cells within it.

FIG. 6. Stone-cells in a cross-section of a tea-leaf.

FIG. 7. The epidermal layer of the lower surface of a leaf of Camellia japonica, showing stomata in the inter-cellular spaces.

PLATE 5.

FIG. 8. The true tea-leaf, showing its characteristic venations.

FIG. 9. Leaves of the black currant, said to be used as an adulterant of tea.

PLATE 6.

Outline sketches of some of the leaves said to be used as adulterants of tea. In the natural condition these leaves vary very much in depth of color. The Sloe and Paraguay tea-leaves are dark green, the beech-leaf is light yellowish-green. By curing and infusion these leaves are changed to a dark greenish-brown hue.

PLATES 7 AND 8

Exhibit the distinctive serrations of the plant leaves used as adulterants of tea, highly magnified. A, A, Tea; B, Willow; C, D, Hawthorn; E, Paraguay tea; F, Sloe; G, Black Currant; H, Ash; I, Beech; J, Camellia japonica. The leaves of the raspberry are said to be used in this country in large quantities in the adulteration of tea. This will be investigated.

OLIVE OIL, LARD, AND THEIR ADULTERANTS.

ORIGINAL INVESTIGATIONS RELATING TO COLOR REACTIONS.

Of late years the demand for olive oil as an article of food and for other purposes has greatly increased. This increased demand and the high price of the pure oil have led to a very extensive and fraudulent practice of adulterating it largely with seed oils. The olive growers of this country and of Europe say that no reliance can be placed upon the so-called olive oils of commerce, unless the buyer procures them directly from the grower, and they affirm that many samples of so-called olive oil consist mostly of cotton-seed oil, which in Italy is poured over the olives in the crusher to thoroughly mix the two oils. Very little pure oil, it is said, is obtainable even in Italy. Southern France has of late years suffered seriously from the artificial fabrication of this, one of her chief products; and the dilution of the olive oils of Nice and Provence with various seed oils has reduced their market value, according to the consular reports, below the point of profitable culture.

It is evident from the foregoing that the olive-oil industry of this country, if not protected by stringent laws, will suffer in like manner. This Department has lately been informed, by one of the leading olive cultivators of California, that although the olive oil of the United States is sold to dealers in its original purity, they mix with it cotton-seed oil, chiefly, but that they also use for this purpose various other seed oils, such as oil of sesame, walnut, sunflower-seed, poppy-seed, peanut, and even lard oil.

For the purpose of discovering new and useful tests for the adulterants of food fats and oils, I have made, during the past year, about fifteen hundred experiments, resulting in the use of the following named chemicals and chemical combinations as tests for the above mentioned adulterants:

Test A, 55 parts sulphuric acid, chemically pure, combined with 45 parts distilled water, by measure. Specific gravity of the mixture 1.575. Temp. 71°.6 Fah., 22° C.

Test B, 55 parts sulphuric acid, chemically pure, combined with 30 parts distilled water, by measure. Specific gravity 1.648. Temp. 71°.6 Fah., 22° C.

Test C, nitric acid, chemically pure. Specific gravity 1.42.

Test D, a solution of nitrate of silver in distilled water in the proportions of an ounce of nitrate of silver, in crystals, to an ounce of distilled water.

In the application of these tests to oils of any description I proceed as follows: Into a test-tube I first pour oil to the depth of about an inch and then an equal quantity of the acid solution. The tube is then corked, violently shaken, and after removal of the cork is placed on its rack. Changes in color should be noted at once. For this purpose I prepare drawings of test-tubes on card-board in advance, and copy the color reactions carefully as they progressively appear. The test-tubes for these experiments should be at least 7 inches long by five-eighths of an inch in diameter. This is especially desirable in the use of the nitric acid test, as the seed oils and lard oil decompose rapidly at about 78°.8 Fah., and will froth over even at a lower temperature, liberating the nitrous acid. The test-tubes should be placed in suitable racks.

The student will observe that in experiments with test B a deeper color is produced than in experiments with test A. With test C the

color reactions on evolution of the nitrous fumes are very interesting, the contrast between those of the true olive oils and those of lard oil and the seed oils showing forcibly the greater attraction of the latter for oxygen. The evolution of the nitrous acid takes place slowly at a temperature of 71°.6 Fah. (22° C.) in the case of the seed oils and lard oil; but if the mixture is exposed to the direct rays of the sun for a few seconds, the liberation of this acid is greatly accelerated, though not in the same degree with each variety of oil. In the case of the true olive oils, the evolution of nitrous acid is very slow, their decomposition, though not uniform in its progress for all varieties, always taking place far less rapidly than that of the other oils named, which is an important fact. The seed oils in all cases are wholly expelled from their test-tubes in the form of bubbles, charged with the fumes of the nitrous acid, while the olive oils, if pure, will manifest but little change under the same temperature. In using the nitric acid test on commercial olive oils (so called) some precaution is necessary in warm weather or in an apartment in which the temperature is above 72° Fah., as, if the olive oil is adulterated largely with cotton-seed oil, an explosion is liable to occur on shaking the test-tube, owing to the rapid evolution of the nitrous acid by the action of the nitric acid on the cotton-seed oil. Such an explosion actually occurred in the course of my own experiments at a temperature of about 72° Fah.

It will be seen in these experiments that, under the influence of each re-agent, two or more distinct layers are produced in the samples in the test-tubes. The lowest layer consists mostly of the test-acid and water, which is generally tinged according to the color reactions of the oil or fat used. The methods described have the advantage of enabling the observer to view several changes of color in the course of one and the same experiment. The success of the experiments depends wholly upon the strength and purity of the chemicals used. In testing several varieties of pure olive oil with concentrated nitric acid the similarity of the color reactions of all the samples is remarkable. Lard oil (which requires further investigation) is similar to olive oil in its color reactions under this test, even to the bands of green and yellow resting on the acid in the test-tube. (See Plate 3, Fig. 1, section *d*.) If the oil of sesame is present in olive oil it may be detected by either test A or B. By the former as small an amount of the adulterant as 5 per cent. may be perceived. By test B a well defined violet tinge is shown in the lower layer in the test tube, and a dark band, characteristic of the oil of sesame, is observed above this, about midway of the tube. The color reactions of the oil of sesame, treated with test A, are different from its color reactions under test B. (See Plate 4, Figs. 3 and 4.)* Pure raw linseed oil under test A yields a most beautiful green color and is opaque, without the dark dividing band observed when this test is applied to the oil of sesame. In the latter case the width of the dark band is proportional to the amount of the oil of sesame used.

* In Figs. 5 and 6 of this plate I have departed from my usual method of mixing the test-acid and the oil or oils by shaking the tubes, in order to ascertain whether the oil of sesame combined with cotton-seed oil would be affected simply by contact with the acid-test without intermixture, and also to note the effect produced by the stronger acid in comparison with that of the weaker. The acid in Fig. 5, test B, almost immediately indicated the presence of the oil as illustrated (see Plate 4, section *a*), while with the weaker acid the indications of sesame did not appear until the day following—showing that oil of sesame when combined with any oil may be quickly detected by the use of the stronger acid-test B.

PLATE 1.

Sections *a*, *b*, and *c* represent the progressive color reactions of seven varieties of pure olive oil. The first six samples were received from the Quito Olive Farm, Santa Clara, Cal.; the seventh sample was from the Bijou Farm, Riverside, Cal. The samples were labeled, respectively, Coreggiolo, Razzo, Mission No. 1, Marajolo, Mission No. 2, Virgin oil, Mission No. 3 (from olives grown in the interior valley, heavy soil, trees irrigated), and are shown in this order in the test-tubes numbered from left to right. Sulphuric acid (test A*) is used. Section *d*, same plate, represents the color reactions of a mixture of cotton-seed oil and known pure lard, combined with benzine in equal proportions. Section *e* represents the color reactions of pure lard dissolved in benzine in the proportions of one of melted lard to two of benzine by measure. In this experiment a solution of nitrate of silver (test D†) is used. The benzine is used in both mixtures to get the lard into a minute state of division and allow the nitrate free access. The color reactions in this case are as observed twenty-four hours after the test was applied. It will be observed that the tubes containing the cotton-seed oil show a yellow color, which represents the cotton-seed oil, while figure 7, section *e*, pure lard, shows no appearance of yellow. The proportion of cotton-seed oil used in the first six tubes is one-half, one-third, one-fourth, one-eighth, one-sixteenth, and five drops, respectively. This section illustrates a method of detecting cotton-seed oil in lard.

PLATE 2.

Sections *a*, *b*, *c*, and *d* represent the progressive color reactions of seven varieties of pure California oilve oil. The nitric acid test (C.‡) is used here. Here as in my other plates the tests tubes are classed in sections for the sake of convenience, the figures denoting the respective oils being the same in each section.

FIG. 1. Coreggiolo.
FIG. 2. Razzo.
FIG. 3. Mission No. 1.
FIG. 4. Marajolo.
FIG. 5. Mission No. 2 (another variety).
FIG. 6. Vergine Oleo. (The first running out of the oil under weigh of the "bruscole" or sacks without mechanical pressure.)
FIG. 7. Mission No. 3.

Section *d* represents not only the advanced color reactions but the progress of the oils in decomposition.

PLATE 3.

Sections *a*, *b*, *c*, and *d* represent the progressive color reactions of the seed oils and lard oil used as adulterants of the pure olive oil. The nitric acid test (C.§) is here used.

FIG. 1. Pure lard oil, which exhibits under this test color reactions similar to those of pure olive oil. (See plate 2.)
FIG. 2. Pure cotton-seed oil.
FIG. 3. Peanut oil.
FIG. 4. Poppy-seed oil.
FIG. 5. Oil of sesame.
FIGS. 6 to 13, inclusive, pure raw linseed oil.

All the above oils oxidize quickly at a temperature of 76° Fah. At 85° Fah. they almost instantly decompose. Any combination of these oils with pure olive oil under this test causes a rapid decomposition even at a temperature of 75° Fah. By this test any sophistication of the pure olive oil with these oils may be detected.

PLATE 4.

Sections *a*, *b*, *c*, and *d* represent the progressive color reactions of, principally, oil of sesame. This oil is more easily detected than any of the seed oils used as an adulterant of olive oil.

FIG. 1. Oil of sesame with an equal portion of pure olive oil, under test B.‖ It is highly important to note the difference in color produced according to the specific gravity of the acid used in this test.

---

* Dilute sulphuric acid chemically pure, specific gravity 1.575, temperature 71°.6 Fah., 22°C.
† Nitrate of silver, 1 to 2 ounces of distilled water.
‡ Chemically pure nitric acid; specific gravity 1.42, temperature 71°.6 Fah., 22° C.
§ Chemically pure nitric acid; specific gravity, 1.42.
‖ Dilute sulphuric acid, chemically pure; specific gravity 1.648, temperature 71°.6 Fah., 22° C.

FIG. 2. Oil of sesame with an equal portion of pure olive oil under test A.*

FIG. 3. Oil of sesame under test B, the oil and the re-agent being in equal proportions.

FIG. 4. Oil of sesame under test A, in equal proportions.

FIG. 5. Oil of sesame and cotton-seed oil in equal proportions under test B.

FIG. 6. Ten per cent. of the oil of sesame, with olive and cotton-seed oils in equal proportions, under test A. In Figs. 5 and 6 the contents of the tubes were not intimately mixed by agitating them until twenty-four hours after the tubes were filled. The contents of Fig. 5, section *a*, indicated the presence of the oil of sesame almost immediately by the dark neutral tint fringing the oil as it rested on the acid. The contents of Fig. 6, same section, but faintly exhibited the purplish color on the day following. On agitating the contents of tubes 5 and 6, the color reactions as represented in sections *b*, *c*, and *d* were observed progressively.

PLATE 5.

Sections *a*, *b*, *c*, and *d* represent the progressive color reactions of pure lard and mixtures of pure lard with cotton-seed oil under the sulphuric acid test A,† using equal portions of benzine in each case as a solvent of the lard.

FIG. 1. Pure lard.

FIG. 2. Pure lard and cotton-seed oil in equal parts.

The test tubes in sections *c* and *d*, Figs. 1 and 2 respectively, represent the appearance of the color reactions after a lapse of seventy-two hours.

---

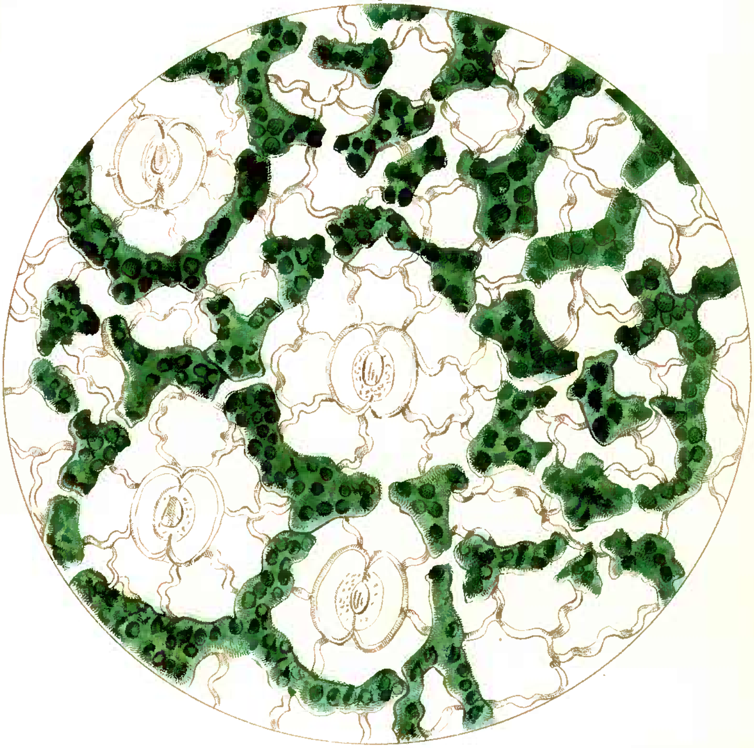
* Dilute sulphuric acid, chemically pure; specific gravity 1.575, temperature 71°.6 Fah., 22° C. All proportions in these experiments not otherwise expressed are by measure.

† Dilute sulphuric acid, chemically pure; specific gravity 1.575, temperature 71°.6 Fah., 22° C.

MICROSCOPIC INVESTIGATION OF THE TEA LEAF.

LOWER EPIDERMIS OF LEAF, SHOWING THE STOMATA AND CHLOROPHYL CELLS.

Fig 1



"STONE CELL" IN CENTER OF THE LEAF Fig. 2

T. Taylor del.

MICROSCOPIC INVESTIGATION OF THE TEA LEAF.

"STONE CELLS" OBSERVED AMONG THE LOOSE CELLS OF THE LEAF.

Fig 3

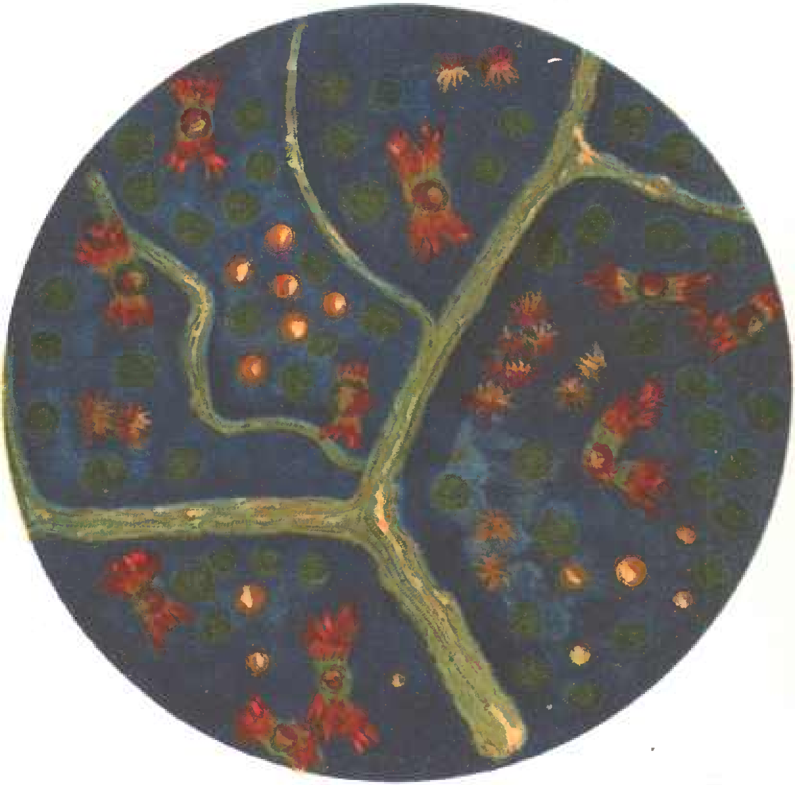
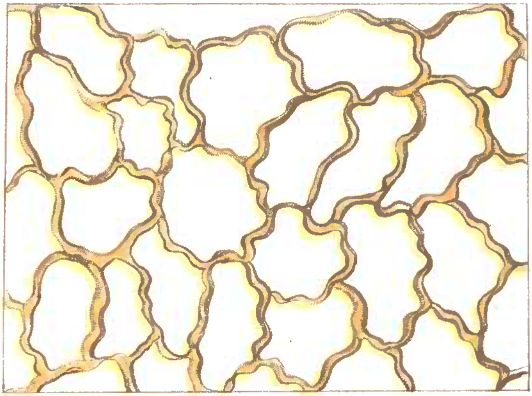


Fig 4

UPPER EPIDERMIS OF THE LEAF.



T. Taylor del.

Sackett & Wilhelms Litho Co. New York

MICROSCOPIC INVESTIGATION OF THE TEA LEAF.

SCLERENCHYMA OR "STONE CELLS" OF THE MIDRIB.

Fig 5

X300

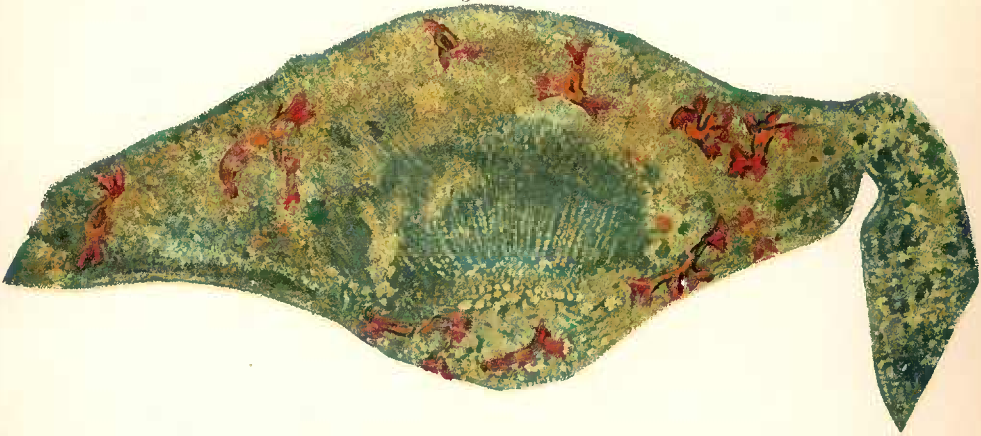
T. Taylor del.

Sackett & Wilhelms Litho Co. New York

MICROSCOPIC INVESTIGATION OF THE TEA LEAF.

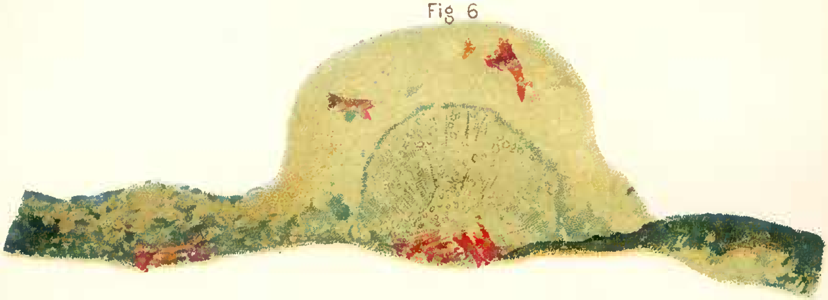
CROSS SECTION OF CAMELLIA JAPONICA LEAF SHOWING STONE CELLS.

Fig. 5



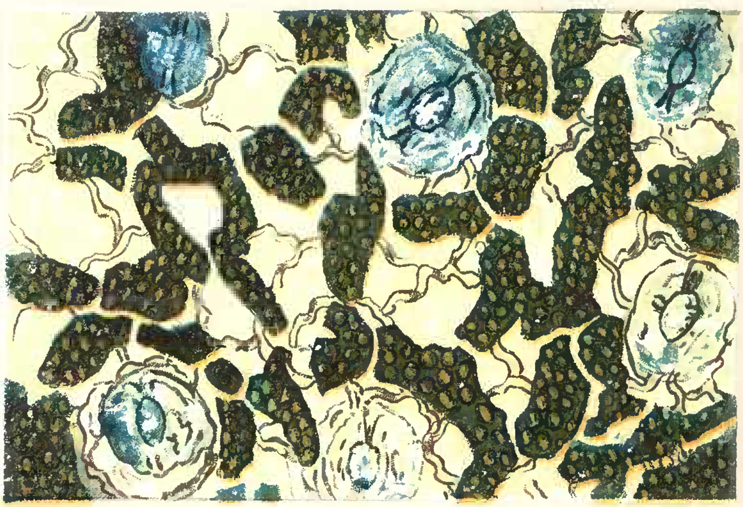
CROSS SECTION OF TEA LEAF SHOWING STONE CELLS

Fig 6



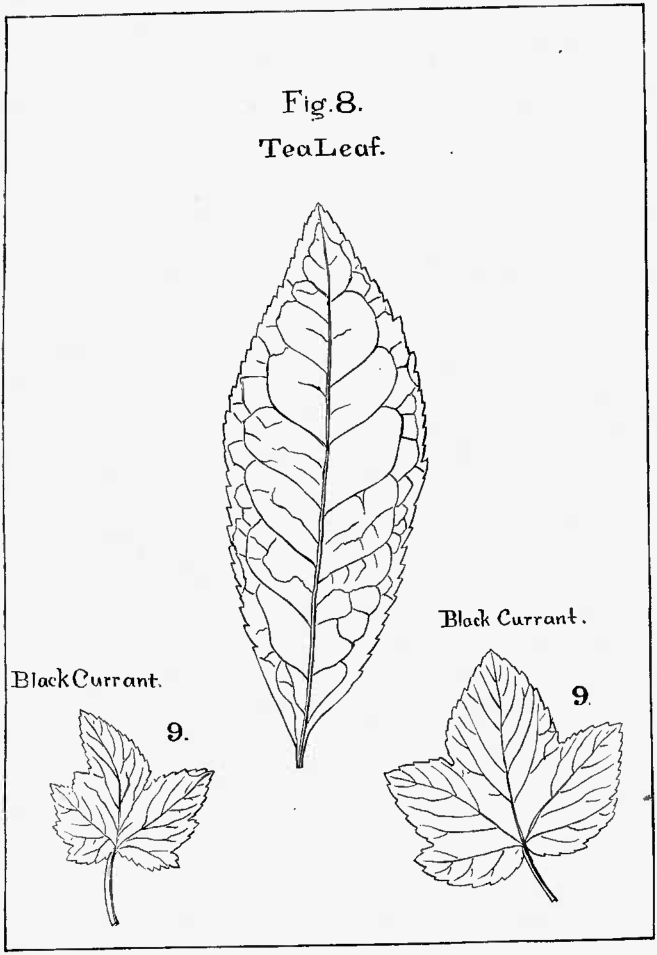
STOMATA OF LEAF OF CAMELLIA JAPONICA.

Fig. 7



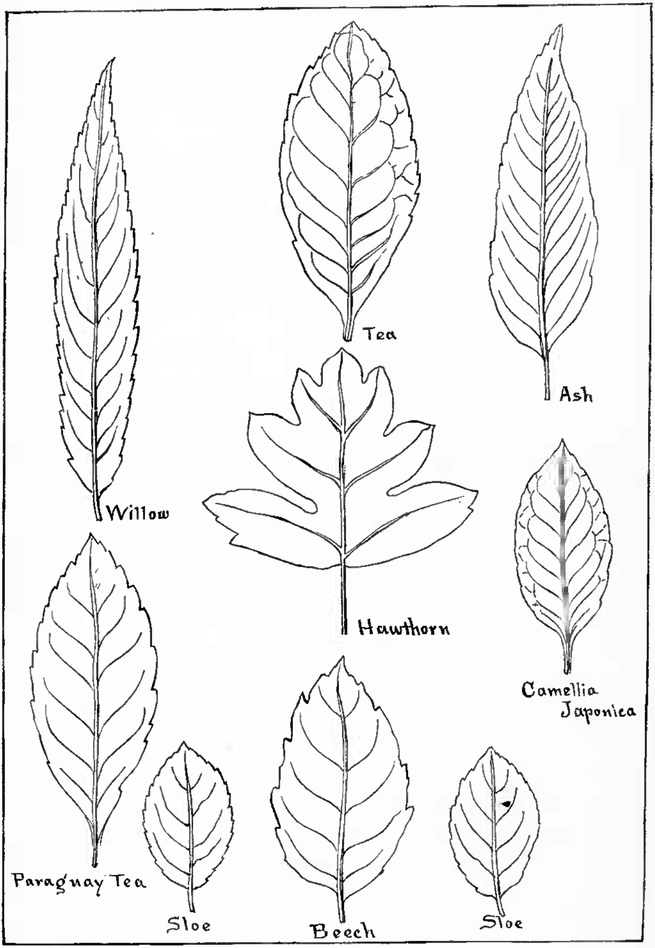
T. Taylor del.

Sackett & Wilhelms Litho Co. New York



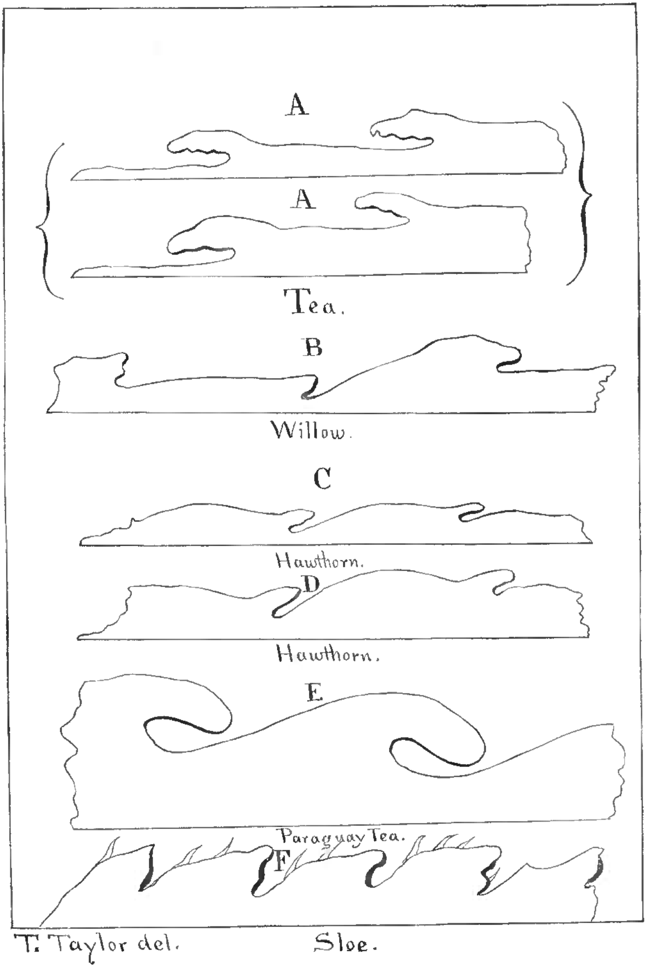
T. Taylor del.

TEA-LEAF AND ITS ADULTERANTS.

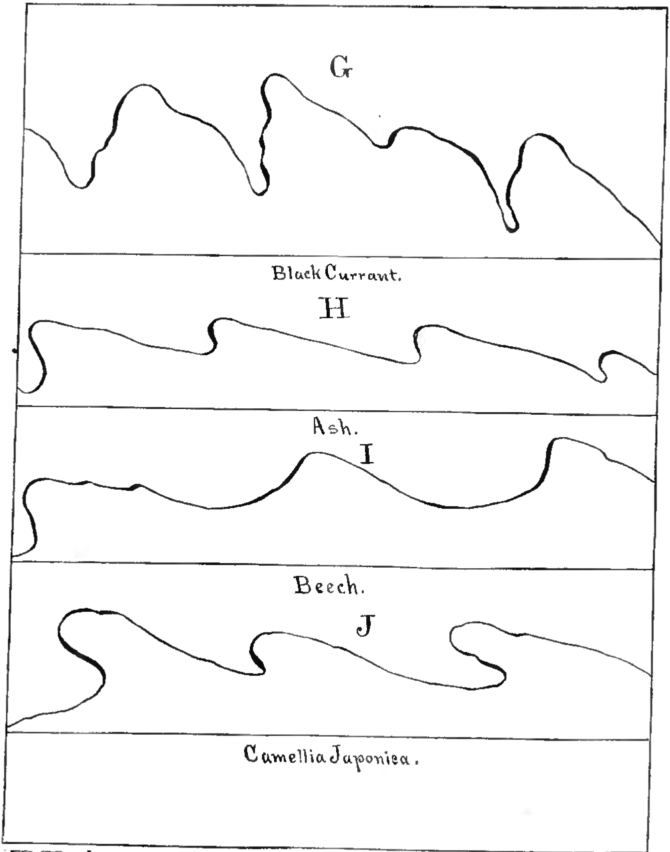


T. Taylor del.

TEA-LEAF AND ITS ADULTERANTS.



DISTINGUISHING SERRATIONS OF THE TEA-LEAF AND ADULTERANTS CONTRASTED.



T. Taylor del.

DISTINGUISHING SERRATIONS OF THE LEAVES SOMETIMES MIXED WITH TEA-LEAVES.

OLIVE OILS

seven varieties

Sections a b and c under test A

First color reaction.

T. Taylor del.

Geo. S Harris & Sons, Lith. Phila.

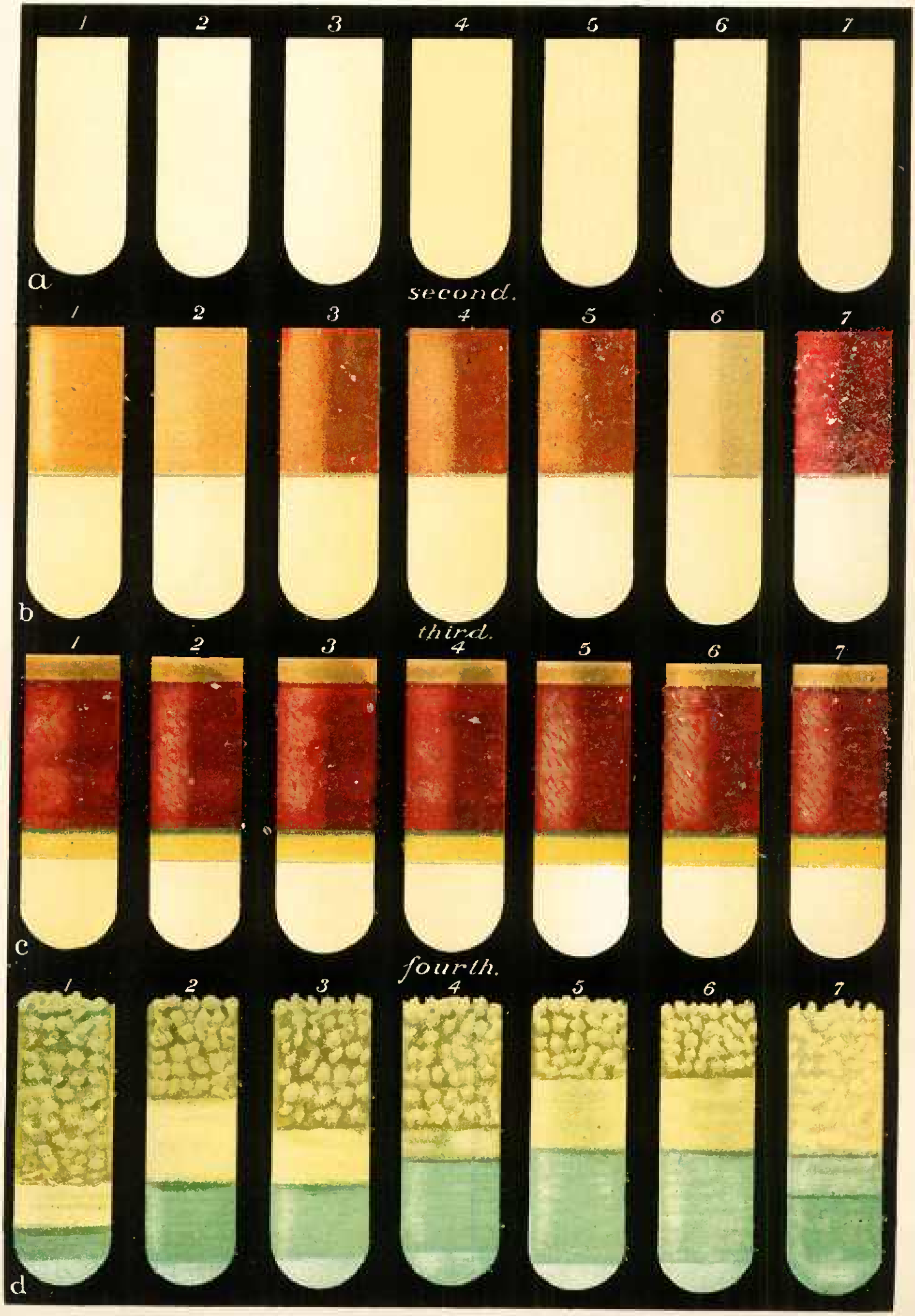
Sections d and e under silver test

OLIVE OILS

seven varieties

Sections a b c and d under test C ☆

First color reaction



T. Taylor del.

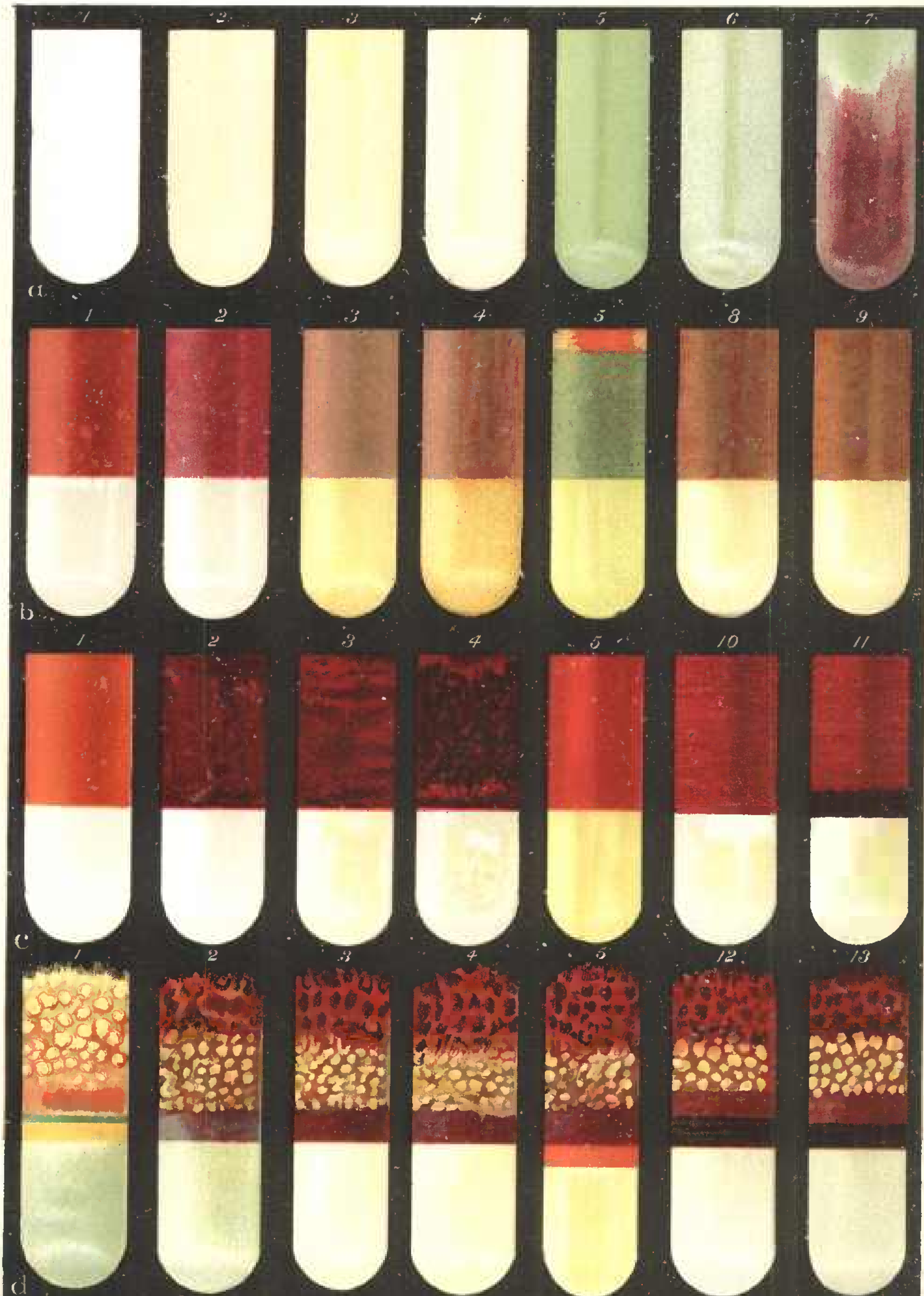
Geo S Harris & Sons, Lith Phila

Last stage under decomposition.

(☆ C. Nitric acid Sp. gr. 1.42.)

COLOR REACTION

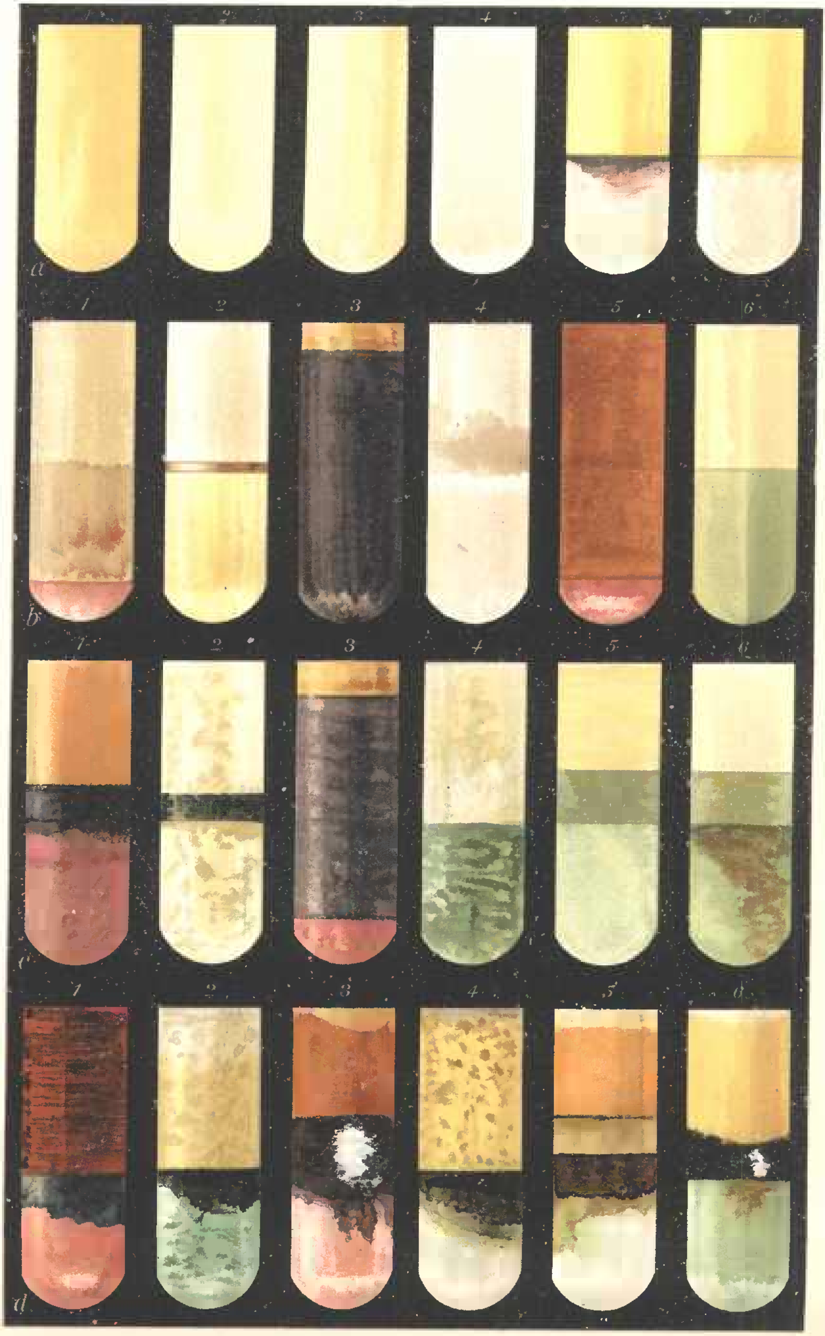
of the seed oils including lard adulterants
of olive oil and lard
under test C ☆



Lard oil. Cotton-seed oil. Peanut oil. Poppy-seed oil. Sesame oil. Raw Linseed oil.

(☆ Nitric acid Sp. gr. 1.42.)

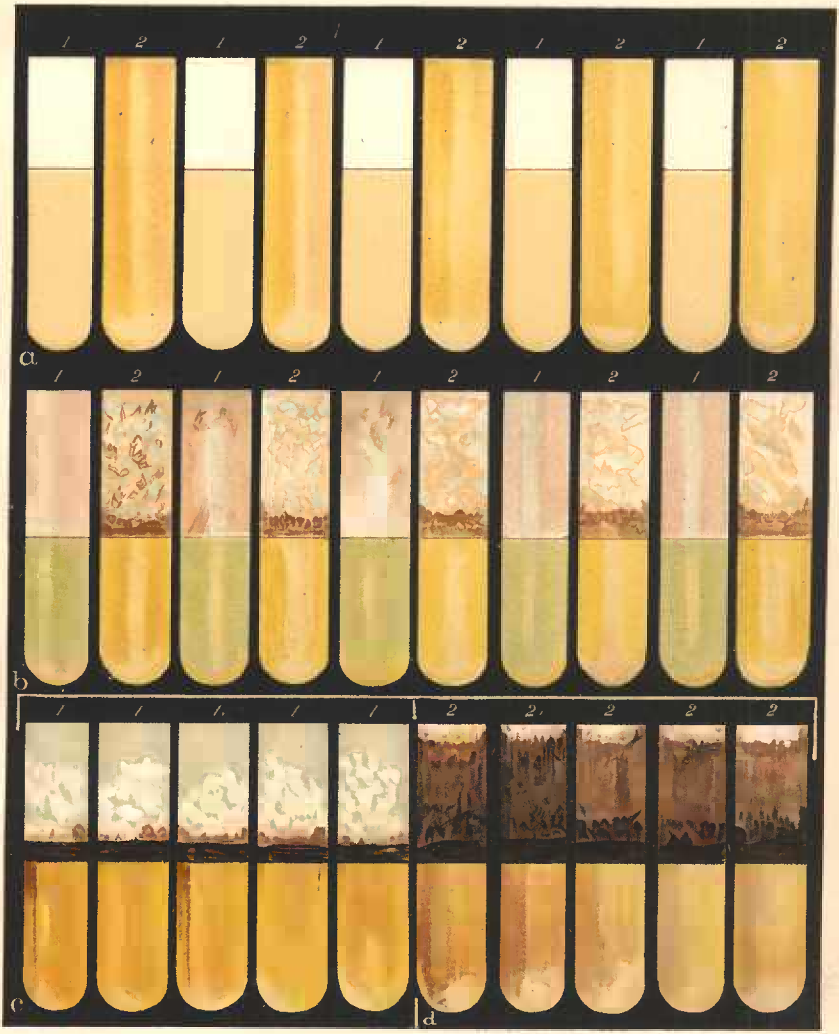
SESAME OIL
and
its detection in Olive oil by two tests – A and B.



T. Taylor del.

Geo. S. Harris & Sons, Lith. Phila.

COLOR REACTION
of
Lard and cotton seed oil and Lard under test A.



T. Taylor del.

Geo. S. Harris & Sons, Lith. Phila.

Pure Lard and benzine.

Pure Lard cotton-seed oil and benzine.

REPORT OF THE STATISTICIAN.

SIR: I have the honor to submit my twenty-first annual report as Statistician of the Department of Agriculture.

While the especial province of the Statistical Bureau is the United States of America, its field is really the world. Several of the products of American agriculture find so large a sale in other countries that their value here is affected if not controlled by foreign prices. This fact renders necessary a knowledge of the probable production of all countries contributing to the world's supply of such products. Further, the tendency to overproduction of staples, from a large annual increase of farm laborers and improved cultivation, requires the fullest and promptest information concerning new fruits, fibers, or products of economic plants, for which a profitable place may be found in some soil at some elevation between the frozen and the torrid zones of the continental areas of the United States. The importation of the products of agriculture and industry which could be produced by domestic labor now only partially employed is a prominent cause of the agricultural depression of which there is so much complaint in the more exclusively agricultural districts of the country, and a remedy must come from practical appreciation of the statistics which show where new values can be created by labor and old drains of national wealth to foreign lands may be closed up. There is reason, therefore, even urgent necessity, for international as well as national statistics in the service of this branch of the Department. A system of statistical investigation for Europe has been inaugurated, in charge of which is an agent in London, who is deputy consul-general, having the co-operation of officials in the foreign service of the United States and of commercial authorities of Europe.

In national statistics there is the co-ordination of results of other organized agencies, as the national census, returns of assessors, conclusions of State boards and departments of agriculture, records of trade organizations, and other current official statistics, in addition to the original work of statistical investigation carried on by this branch of the Department service. This service runs in various lines and makes researches concerning the changes of production, the course of distribution, the cost of transportation, the rate of consumption, and the range of prices.

A branch of this service which has attracted much attention is crop reporting, or indicating in advance of harvest the approximate outcome. It is well to have records of production for comparison and analysis for many practical purposes; but the vital want of to-

day is a clear and searching glance into the future, a forecast of crop results which shall fairly indicate them in advance. This must be a matter of estimate, the truth and utility of which depends on thorough observation and reliable judgment in the reporter, and critical acumen and mathematical skill in the consolidation. A board of observers in each county, about twelve thousand in all, make the county comparisons and estimates. A list of much more than one hundred thousand individual farmers is drawn upon for specific information, and especially for areas and products of their principal crops in comparison with such data for the previous year, to test the rate of yield, as well as to show the changes in distribution of crops.

The benefit to farmers resulting from the publicity of crop reports is measured in millions of dollars. It is now impossible for speculators to misrepresent successfully the crop situation to depress temporarily the prices until they can obtain possession of large fragments of salable crops. The crop report is a regulator of the market, which reduces to a minimum the effect of exaggerations put forth to cause wide fluctuations in market prices. A knowledge of crop conditions, to be of any use to the farmer, must have the widest publicity in the marts of trade as well as on the farms. It can not annul the law of supply and demand, but it can largely control the temporary fixing of prices in violation of that law.

Another line of practical statistics intended to aid the farmer in marketing his products to the best advantage is the collection of data relating to the cost of transportation of farm products by land or water. The freight tariffs of the main lines of railroads are published monthly, and changes are noted as they occur, for the products of agriculture which seek distant markets. While the current transportation rates, the nominal rates at least, are thus made known to producers, the service labors under the disability of being unable to give the reductions, abatements, the special rates made to favored individuals, which modify actually the nominal rate and reduce the average cost of transportation to the injury of the great mass of forwarders. Yet the information is valuable, affording means of comparison of the cost by different lines to prominent centers of distribution and to the seaboard, at least approximately. The most remarkable fact in connection with transportation facilities is the reduction in the rates during the past twenty years, as the result of the increase of railway construction and consequent competition, even more than the effect of regulative or restrictive legislation. It is probable that few foresaw the extent and rapidity of the reduction of the cost of transportation, which has so much benefited western farmers and at the same time forced an injurious competition upon Eastern agriculturists, and compelled a redistribution of production in Eastern rural industry.

CURRENT CROP PRODUCTION.

A prime factor in agricultural production is found in the meteorology of the growing season, which in portions of the country includes the twelve months of the year. The liability to serious injury from irregular rain-fall or absence of precipitation for a considerable period is always an element of uncertainty. Drought is a prolific cause of low yields, and the primitive culture characterized

less by labor-saving than by the avoidance of labor intensifies the depreciation. This liability is greater in some sections than in others, but no large district of the country is entirely exempt from loss through deficient or irregular rain-fall and high temperature.

The past season has been free from losses from drought, except in limited areas. The precipitation was slightly lower than the normal rain-fall of the United States. There was an excess in the Eastern and Middle States; the South Atlantic States had a very unequal distribution, a deficiency in May and September, and a large excess in June, with an average nearly normal. A deficiency existed till June in the eastern Gulf States, when an excess was precipitated with moderate rain-fall afterwards. The western Gulf States had a nearly full supply, insufficient in April and May, but very abundant in June and July. Fears of drought were entertained in April throughout the Ohio Valley, which were dispelled by ample rain-fall in May and June. In the more northern belt, from Michigan to Dakota and the mountains of the Northwest, there was a deficiency which was somewhat seriously felt in the summer months, reducing the yield of corn and spring wheat and other summer crops. The Pacific coast had more than average rain-fall, with some inequality in the distribution. The records of the Signal Service make the following comparisons:

Districts.	Rain-fall.			Departure of 1889 from the normal.	Departure of 1888 from the normal.
	For a series of years.	For 1889.	For 1888.		
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
New England	23.24	26.47	22.95	+3.23	+1.04
Middle Atlantic	23.70	34.09	24.86	+10.39	+1.51
South Atlantic	32.12	31.68	26.52	—0.44	—5.14
Eastern Gulf	30.37	28.63	34.83	—1.74	+3.67
Western Gulf	23.00	22.80	28.76	—0.20	+4.91
Ohio Valley and Tennessee	23.21	22.59	22.45	—0.62	—0.62
Lower Lake region	18.20	16.48	15.98	—1.72	—3.13
Upper Lake region	20.11	18.60	16.26	—1.51	—3.81
Extreme Northwest	14.36	9.63	12.70	—4.73	—1.46
Upper Mississippi Valley	22.94	19.91	22.73	—3.03	—0.28
Missouri Valley	21.50	18.35	19.75	—3.15	—1.93
North Pacific coast	15.13	14.22	13.70	—0.91	—1.25

The temperature of the year was below normal for the whole country; high in New England from April to June, inclusive; in the Middle and South Atlantic States in April and May; in the Missouri Valley and the extreme Northwest in August; in the Rocky Mountains through the summer; and for most of the season on the Pacific coast. It was slightly below normal from June to September in the Middle Atlantic States, and in August and September a still greater depression in the South Atlantic States; it was below normal on the Florida Peninsula from April to August, below in the Gulf States, especially in September; in the Ohio Valley a depression from May through the season. The comparative temperature is thus shown:

Average temperature by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1889.	For several years.	1889.	For several years.	1889.	For several years.	1889.	For several years.	1889.	For several years.	1889.
	°	°	°	°	°	°	°	°	°	°	°	°
New England	43.8	45.9	54.0	56.2	63.4	64.8	66.7	65.1	67.5	66.5	62.0	62.0
Middle Atlantic States	52.0	53.8	63.4	64.1	71.5	70.9	76.5	75.2	74.1	72.3	68.9	66.3
South Atlantic States	61.6	62.1	70.7	71.4	78.1	77.0	80.8	80.0	79.1	76.9	75.0	73.5
Florida Peninsula	73.5	71.1	78.0	75.4	82.0	79.7	84.0	82.3	83.5	80.8	81.5	80.4
Eastern Gulf States	66.5	67.0	73.7	71.1	79.7	77.0	81.5	81.1	80.7	78.6	76.8	75.6
Western Gulf States	67.3	68.4	73.7	71.2	80.6	76.9	83.2	82.2	82.1	79.9	77.1	73.4
Rio Grande Valley	76.0	75.2	80.5	77.3	84.0	83.3	86.0	86.0	84.4	84.4	81.0	77.8
Ohio Valley and Tennessee.	56.4	57.3	66.8	64.3	73.7	70.4	77.6	76.6	75.7	73.2	70.2	67.1
Lower Lake region	44.3	45.6	57.9	57.5	66.2	63.9	71.2	70.7	69.1	68.0	64.2	62.7
Upper Lake region	40.3	42.4	52.6	51.5	61.3	58.3	66.9	67.0	65.5	66.4	59.4	59.0
Extreme Northwest	39.8	46.4	55.3	51.5	64.2	63.8	68.0	67.0	66.3	68.3	55.5	53.6
Upper Mississippi Valley	51.7	52.8	63.3	60.6	71.3	67.5	75.8	74.3	73.6	72.5	65.8	63.4
Missouri Valley	48.5	52.1	61.0	59.2	70.4	68.7	74.4	73.6	72.7	73.2	64.2	61.3
North Pacific coast region.	49.4	52.2	54.7	56.4	58.6	60.7	62.0	63.8	61.6	60.4	57.6	57.3
Middle Pacific coast region	57.3	60.4	65.0	63.3	67.4	70.0	71.6	70.9	70.3	71.4	68.0	70.8
South Pacific coast region.	59.5	61.3	63.0	61.7	66.5	65.2	74.5	69.2	71.0	71.2	68.0	71.4

The departure from the normal, both in temperature and rainfall, in each month of the growing season is thus shown by the records:

Districts.	April.		May.		June.		July.		August.		September.	
	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.	Temperature.	Rain-fall.
	°	*In.*	°	*In.*	°	*In.*	°	*In.*	°	*In.*	°	*In.*
New England	+2.1	−0.12	+2.2	+0.37	+1.4	+0.06	−1.6	+2.71	−1.0	−0.39	0.0	+0.60
Middle Atlantic	+1.8	+2.93	+0.7	+2.00	−0.6	+0.92	−1.3	+3.85	−1.8	−0.92	−2.6	+1.59
South Atlantic	+0.5	−0.25	+0.7	−1.48	−1.1	+2.57	−0.8	+0.97	−2.2	−0.38	−1.5	−1.87
Eastern Gulf	+0.5	−3.01	−2.6	−2.48	−2.7	+0.46	−0.4	+3.03	−2.1	−0.36	−1.2	+0.62
Western Gulf	+1.1	−1.06	−2.5	−2.17	−3.7	+1.77	−1.0	+1.36	−2.2	−0.48	−3.7	+0.38
Ohio Valley and Tenn.	+0.9	−2.03	−2.5	+0.42	−3.3	+0.65	−1.0	−0.22	−2.5	−1.20	−3.1	+1.76
Lower Lake region	+1.3	−0.00	−0.4	+0.15	−2.3	+0.90	−0.5	−1.08	−1.1	−1.19	−1.5	−0.50
Upper Lake region	+2.1	−0.14	−1.1	+0.15	−3.0	−0.32	+0.1	+0.71	+0.9	−1.26	−0.4	−0.65
Extreme Northwest	+6.6	−0.88	−3.8	+0.18	−0.4	−2.33	−1.0	−1.22	+2.0	−1.39	−1.9	+0.91
Upper Mississippi Val	+1.1	−0.75	−2.7	+0.12	−3.8	−0.74	−1.5	+0.53	−1.1	−1.56	−2.4	−0.63
Missouri Valley	+3.6	+0.17	−1.8	−0.84	−1.7	−1.95	−0.8	−0.22	+0.5	−0.62	−2.9	+0.31
North Pacific coast	+2.8	−0.40	+1.7	+0.10	+2.1	−1.30	+1.8	−0.92	−1.2	+1.89	−0.3	−0.28
Middle Pacific coast	+3.1	−1.87	−1.7	+1.78	+2.6	−0.05	−0.7	−0.01	+1.1	−0.01	+2.8	−0.33

With such a meteorological record, without sharp divergence from normal lines, medium crops might reasonably be expected. There were no extraordinary averages, no very large harvests, and no failures. There were conditions unfavorable to some crops in one section, and those that were quite favorable in another. The geographical breadth and climatic variety of the national area tend to equalize production in every line. The cereals have the range of the whole country, by choosing the proper season of growth, and the subtropical fruits are not limited to the South Atlantic coast but have a wide range on shores of the Mexican Gulf and the Pacific Ocean.

The increase in area of corn over that of the previous year appears to be about 3½ per cent., or slightly more than the increment of population. Unless the annual estimates have been too low the in-

crease of the past ten years has not quite kept pace with the advance of population, though the gain in breadth of maize is 26 per cent. The exportation is less than ten years ago, almost necessarily, the abnormal shipments of that period being due to a temporary scarcity of grain products in western Europe. This would account for a reduction of two million acres of the required area. The increase in the breadth west of the Mississippi has been remarkable, the proportion of increase rising with advance westward at least up to 3,000 to 4,000 feet elevation beyond the western boundaries of Kansas and Nebraska. The product of the crop is estimated at 2,112,892,000 bushels, or about 27 bushels per acre, which is the largest rate of yield since 1880.

The area in wheat, as estimated, is larger than last year by over 2 per cent. The revision of acreage reduces the breadth in Iowa, Nebraska, and some other States, and increases it in Kansas and Dakota. Dairying and meat production have for years been encroaching on wheat growing on the eastern side of the great spring-wheat belt, and the change from wheat to corn and grass has been especially noticeable in Iowa. The rise and fall in prices and the relative promise of the profit in the various crops are prominent among the economic considerations which affect the distribution of crops, and especially of wheat. The wheat product is made 490,560,000 measured bushels. This makes the average yield 12.9 bushels, about 1 per cent. above the indications in the local estimates of yield per acre published in October.

The indications of all reports after June last were quite uniform, extreme differences being not more than 1 or 2 per cent. It is significant, as well as complimentary, that a variation of a fraction of 1 per cent. is sufficient to excite the attention and remark, not to say the criticism, of the speculative traders in wheat.

The increase in the area of oats appears to be nearly 2 per cent.; the product 751,515,000 bushels, or 27.4 bushels per acre.

The minor cereals make about the usual product, and constitute between 2 and 3 per cent. of the aggregate production. In this statement rice is not included. There has been a considerable increase in production, notably in Louisiana, and manifestly on much of the rice area of the Atlantic coast. It is difficult to get precise returns of this scattered and peculiar growth except through a thorough census.

The potato crop of the present year has been a comparative failure east of the Alleghanies, while the Western crop has been in some States medium and in others large, making the aggregate production nearly the same as that of the previous year. The December returns of prices make the average 40.3 cents per bushel against 40.4 cents last December.

The crop of sweet potatoes is larger than that of last year, with a yield somewhat above the average.

There has been a manifest advance in the sugar-cane industry in recent years. The Louisiana crop of 1888, which is 267,881 hogsheads by the Bouchereau census, is the largest, with one exception, since 1861, when the aggregate was 459,419, the largest ever produced. Planters are hopeful, under the encouragement of better machinery and methods, soon to swell the production of cane-sugar to a larger figure than the industry has yet attained. The present crop looked well at first, but was less promising in mid-summer. The October condition, however, indicated a nearly medium crop on a large area.

The sorghum crop has been a medium one in the central States and in the Southwest. On the Atlantic coast the excess of rainy and cloudy weather reduced somewhat the value of the crop. The interest in sorghum as a sugar plant is increasing in the Southwest, and experiment is still rife for the production of sugar by the diffusion process.

The beet as a sugar plant is extending its area on the Pacific coast, and promises to return again to cultivation in the central valleys and the eastern coast. The product is not yet greatly increased.

The hay crop of 1889 is a large one, and the average price has declined. The December returns make the present average $7.88 per ton.

The cotton crop is the largest in the aggregate, but not in yield per acre, that has ever been made, exceeding the two preceding crops of 7,000,000 bales. The increasing demand for this fiber sustains the price, which fluctuates less than that of most other crops. There is more interest than usual in other fibers. Flax grown mainly for its seed is the subject of experiment as a textile product; hemp is slowly increasing its area, and ramie and jute and many other fibers are grown experimentally, as they would be extensively were successful machinery for decortication in practical operation.

The apple crop is a small one, and the market orchard regions were destitute of their usual resources except as high prices have rewarded successful cultivators and owners of off-year orchards. Other fruits have made better local averages of results. The product of citrus fruits, raisins, figs, guavas, and many other subtropical varieties, is increasing in quantity on the Pacific and Mexican Gulf coasts, exciting more attention annually, and holding out a promise of better profits as their cultivation is better understood. Already they are taking the place of foreign fruits, the importation of which is declining, especially of oranges and lemons, raisins and prunes.

The production of meats is increased by forcing to medium weights at an earlier age, making the number of available beeves larger in proportion to numbers of animals counted in an annual enumeration. The difference between the prices paid to farmers and the cost of meat to consumers is enormous, inuring to the benefit of the middleman and injuring the grower.

The wool clip of the fall of 1888 and spring of 1889 was estimated at 265,000,000 pounds, but the product of the current wool year, the fall shearing and coming spring clip, promises to be somewhat larger, with a tendency to revival of interest in sheep husbandry. Its growth has doubled the weight of fleece in about thirty years, as a result of breeding and care under the stimulation of demand from our growing manufactures. The necessity and relatively appreciating price of fine mutton should stimulate the industry in all States east of the great plains, and discrimination against the cheap wools of nomadic wool-growing would enlarge the production of coarse wools in the great southwestern pastoral areas.

The humidity of the past season has been generally favorable to pasturage, and vegetable production has been various and abundant.

CORN.

The crops of the last ten years make a lower average than those of the previous decade. The cause is the frequent recurrence of drought and not a decrease in fertility. Since 1880 only three crops have

made an average of 26 bushels. From 1875 to 1880, inclusive, no crop fell below this average, and the yield for the decade beginning in 1871 exceeded it. The crops of the last two years have been a great improvement upon nearly all from 1881 to 1887, inclusive. The general average of condition of the crop of 1887, the year of drought in the corn belt, contrast irregularly with the records of the crops since, and show the blighting effects of widespread drought in that year as follows:

Years.	July.	August.	September.	October.
1887	97.7	80.5	72.3	72.8
1888	93.0	95.5	94.2	92.0
1889	90.3	94.8	90.9	91.7

The area devoted to maize still continues to represent more than half the breadth of all cereals, and averages about 1.2 acres per head of population, or 6 acres to each family in the United States.

The estimates of the crop of 1889 are as follows:

States and Territories.	Bushels.	Acres.	Value.
Maine	1,034,000	28,717	$589,273
New Hampshire	1,311,000	35,924	734,287
Vermont	2,044,000	58,397	1,124,142
Massachusetts	1,997,000	58,209	1,078,147
Rhode Island	393,000	12,558	220,116
Connecticut	1,766,000	56,977	953,795
New York	20,475,000	698,800	10,032,672
New Jersey	10,792,000	357,342	5,395,864
Pennsylvania	41,225,000	1,383,377	18,963,332
Delaware	3,905,000	223,136	1,640,050
Maryland	15,105,000	733,239	6,495,031
Virginia	34,231,000	2,152,911	15,061,765
North Carolina	33,050,000	2,754,127	17,516,248
South Carolina	18,310,000	1,592,152	9,887,264
Georgia	23,730,000	3,011,602	18,551,468
Florida	5,206,000	486,562	3,019,604
Alabama	33,944,000	2,514,370	17,311,437
Mississippi	29,474,000	1,991,481	14,736,960
Louisiana	18,949,000	1,082,826	9,664,222
Texas	83,698,000	4,573,645	29,294,196
Arkansas	42,608,000	2,130,399	18,321,431
Tennessee	80,831,000	3,674,140	29,907,500
West Virginia	15,199,000	678,518	6,079,521
Kentucky	75,382,000	2,844,601	25,629,855
Ohio	88,953,000	3,005,184	27,575,568
Michigan	22,737,000	967,513	8,412,526
Indiana	106,656,000	3,677,808	28,797,237
Illinois	259,125,000	8,022,454	62,190,063
Wisconsin	28,415,000	1,080,414	8,240,318
Minnesota	21,263,000	746,067	5,740,986
Iowa	349,966,000	8,859,898	66,493,534
Missouri	218,841,000	6,796,318	50,338,531
Kansas	240,508,000	6,813,251	43,291,397
Nebraska	149,543,000	4,097,067	25,422,301
California	4,464,000	158,238	2,544,322
Oregon	157,000	7,854	102,102
Colorado	1,092,000	42,993	633,373
Dakota	14,743,000	819,068	4,865,264
New Mexico	1,126,000	56,289	675,468
Utah	644,000	35,175	392,659
Total	2,112,892,000	78,319,651	597,918,829

While the crop is grown throughout the United States, except on elevations of over 5,000 feet, with much differentiation as to varieties, height, form, and color of grain and chemical constitution, it is more productive in the middle latitudes and the central valleys, being smaller in stalk and ear in more northern regions, and increasing in size but not in fruitfulness in more southern districts. Soil and

cultivation have much to do with relative productiveness, and these causes, as well as climate, must be taken into consideration in examining the following table, which shows the average yield per acre for a period of ten years, 1879 to 1888 inclusive, consolidated from annual estimates of the Department of Agriculture and arranged in the order of relative rank in rate of production:

States.	Average yield.	States.	Average yield.	States.	Average yield.	States.	Average yield.
Vermont	34.3	Iowa	30.2	Washington	25.7	Texas	18.0
New Hampshire	34.1	Connecticut	29.7	Maryland	25.0	Virginia	17.1
Maine	33.9	Indiana	29.3	Nevada	24.6	Louisiana	16.3
Nebraska	32.7	Wisconsin	29.1	West Virginia	24.2	Mississippi	14.2
Massachusetts	32.1	California	28.5	Kentucky	23.8	North Carolina	12.7
Ohio	31.7	Kansas	28.3	Idaho	23.2	Alabama	12.5
Pennsylvania	31.7	Colorado	27.7	Utah	22.5	Georgia	10.4
New Jersey	31.1	Dakota	27.5	Arizona	20.9	Florida	9.4
Michigan	30.9	Missouri	27.0	Delaware	20.8	South Carolina	9.0
Minnesota	30.8	Illinois	26.3	Tennessee	20.6		
New York	30.5	Montana	26.2	Arkansas	20.2	Average	24.2
Rhode Island	30.3	Oregon	26.0	New Mexico	20.1		

It is obvious to all that the figures of a perfect census of a single year would be manifestly unjust as a basis of an exhibit of relative productiveness. The annual fluctuations in rate of yield are so wide that nothing less than a period of ten years should be averaged for this purpose. Such an average can be relied on as the real measure of the production of the period. The average of ten years, however, stated at 24.2 bushels, is probably less than a normal average, as there were six seasons of partial failure in the ten years, while the average of the preceding ten years was 27.1.

The high yield of the New England States is the result of fertilization and careful cultivation of small areas. Nebraska, partially in the arid region, stands in front of all other Western States. The fact that Indiana occupies the fifteenth place and Illinois the twenty-second is due to the severity of drought in 1881 and 1887, and a degree of injury in other years. It is true in this period, whatever future experience may be, that the subhumid belt has given better yields than some of the best districts of the Ohio Valley.

Maize is a crop consumed *in situ*, not more than one-sixth going beyond the boundary of the county in which it is grown. Only 2 to 3 per cent. is now exported; a larger quantity goes to the seaboard States north of Maryland, and a smaller proportion is distributed through the Southern States to supplement the nearly sufficient local supply.

The amount required for consumption is a variable quantity, dependent on price, other and cheaper feeding material being more largely used when the price is high. The same cause restricts exportation, which comes nearly to a vanishing point when the highest price prevails, and reaches its largest proportions when the product is cheapest. The average consumption for ten years past has been about 1,600,000,000 bushels, or 28 bushels per head of population, which is the heaviest rate of consumption of any cereal by any country in the world. It is nearly twice as much, according to population, as the consumption of all cereals in Europe, where roots and various fodder plants are used in feeding, supplemented by small quantities of oil cake or other concentrated fortifiers of green and watery plants.

Nearly two-thirds of the crop is produced in seven States—Ohio,

Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska—which are known as the corn-surplus States, few others rarely producing more than is required at home, and the larger portion having a deficiency to be supplied by those seven States.

The average product of the last ten years, as estimated, is 1,703,443,054 bushels; that of the preceding decade, 1,184,486,954, an increase of 43.8 per cent. The average value of the whole crop for the recent period is $668,942,370, against $504,571,048, an increase in value of only 32.6 per cent. The price per bushel is 39.3 cents, instead of 42.6 cents for the previous decade. The value per acre is reduced from $11.54 to $9.48. The following table gives these estimates by years:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	1,717,434,543	62,317,842	$679,714,499	39.6	27.6	$10.91
1881	1,194,916,000	64,262,025	759,482,170	63.6	18.6	11.82
1882	1,617,025,100	65,659,545	783,867,175	48.4	24.6	11.94
1883	1,551,066,895	68,301,889	658,051,485	42.4	22.7	9.63
1884	1,795,528,000	69,683,780	640,735,560	35.7	25.8	9.19
1885	1,936,176,000	73,130,150	635,674,630	32.8	26.5	8.69
1886	1,665,441,000	75,694,208	610,311,000	36.6	22.0	8.06
1887	1,456,161,000	72,392,720	646,106,770	44.4	20.1	8.93
1888	1,987,790,000	75,672,763	677,561,580	34.1	26.3	8.95
1889	2,112,892,000	78,319,651	597,918,829	28.3	27.0	7.63
Total	17,034,430,538	705,434,573	6,689,423,698			
Annual average	1,703,443,054	70,543,457	668,942,370	39.3	24.1	9.48
Annual average for preceding ten years	1,184,486,954	43,741,331	504,571,048	42.6	27.1	11.54

The export of corn was small until 1870. In 1871 it comprised 3.6 per cent. of the crop, and increased to 6.5 per cent. in 1877, the largest percentage but not the largest aggregate of annual exportation, which was 99,572,329 bushels, 5.7 per cent. of the product, in 1879. This active exportation between 1876 and 1880 has declined greatly, and has averaged only 53,464,476 bushels for nine crops since 1880. These figures include the corn meal exportation reduced to corn. The largest shipments in later years are 70,841,673 bushels from the crop of 1888, when corn had declined to 34.1 cents (average farm price) per bushel. The smallest aggregate is 25,360,869, from the crop of 1887, when the average price was 44.4 cents per bushel. The domestic price is a potent regulator of the foreign demand, and the foreign orders are too small to affect materially the value here; thus Liverpool does not set the price for Chicago.

The average farm price for the entire crop, and the average export price or value at the ports of shipment of actual exports of the fiscal year following, are thus stated, from the year 1875:

Years.	Value.		Years.	Value.	
	Farm.	Export.		Farm.	Export.
	Cents.	*Cents.*		*Cents.*	*Cents.*
1875	42.0	67.2	1882	48.4	68.4
1876	37.0	58.7	1883	42.4	61.1
1877	35.8	56.2	1884	35.7	54.0
1878	31.8	47.1	1885	32.8	49.8
1879	37.5	54.3	1886	36.6	48.0
1880	39.6	55.2	1887	44.4	55.0
1881	63.6	66.8	1888	34.1	47.4

It must not be understood that the difference between farm and export values represents the whole cost of transportation and other charges. Few of the States produce a surplus for export. Export wheat comes mainly from beyond the Mississippi, where prices are the lowest; for instance, the farm price of 1888, corn was 29 cents in Illinois, 31 in Indiana, 26 in Kansas, and 22 in Nebraska, or little more than half the export values.

WHEAT.

The seeding of winter wheat in the autumn of 1888 was delayed in the Middle States by the saturation of the soil, and in the Ohio Valley because it was too compact and hard in consequence of drought for breaking properly. Early rains came in California, followed by a dry season in the heart of the winter, which gave place to later rains in season for the putting in of a large area, and for prompt germination and active spring growth. Rains duly relieved the situation in the central areas, and the soil of the Atlantic coast region became drier, so that the coming of winter found the plants fairly well rooted, green, and vigorous, with a necessarily moderate development from comparatively late planting.

There was little show for winter protection, yet the season was so mild that growth continued, and the effects of freezing and thawing were not very severe. If the plants in April were brown and sere from the touch of the low temperature of March, the roots were generally uninjured and the crowns green. It was a season of exemption from winter-killing in a high degree, notwithstanding the absence of snow, encouraging the expectation of a large crop, though not absolutely assuring it.

April was generally favorable and condition slightly improved during the month. This was also hopeful, as a decline in this month had been noted for the two previous crops. Some apprehension was caused by very cool nights, with frost in many places, near the close of May, which was dispelled by better weather following.

Spring wheat was remarkably uneven in condition, especially in Dakota. Many discouraging reports also came from Minnesota. The soil was dry at seeding on the uplands and plains, and drought in summer threatened serious disaster, which resulted measurably in the region of minimum rain-fall and on areas of poor preparation.

The following table gives the estimates of area, product, and price for 1889:

States and Territories.	Bushels.	Acres.	Value.
Maine	589,000	41,457	$588,689
New Hampshire	144,000	9,342	143,867
Vermont	325,000	19,675	308,406
Connecticut	30,000	1,934	27,579
New York	8,929,000	647,010	8,035,864
New Jersey	1,711,000	140,235	1,573,998
Pennsylvania	16,617,000	1,350,946	14,124,141
Delaware	1,100,000	94,790	879,651
Maryland	6,171,000	546,064	4,998,124
Virginia	6,804,000	810,057	5,851,852
North Carolina	4,492,000	724,473	4,042,560
South Carolina	1,191,000	198,454	1,131,188
Georgia	2,388,000	378,197	2,334,988
Alabama	2,502,000	357,377	2,451,606
Mississippi	494,000	75,938	488,661
Texas	6,139,000	600,837	4,579,580
Arkansas	1,794,000	236,008	1,534,612
Tennessee	9,085,000	1,211,394	6,904,946

States and Territories.	Bushels.	Acres.	Value.
West Virginia	3,144,000	308,251	$2,609,653
Kentucky	10,811,000	982,831	7,784,022
Ohio	36,865,000	2,524,930	28,017,289
Michigan	23,709,000	1,612,847	17,544,550
Indiana	41,187,000	2,801,803	29,242,418
Illinois	38,014,000	2,375,863	26,609,666
Wisconsin	16,937,000	1,192,750	11,686,565
Minnesota	45,456,000	3,113,406	30,455,338
Iowa	21,023,000	1,604,838	13,244,728
Missouri	20,639,000	1,587,583	13,208,691
Kansas	30,912,000	1,680,000	17,001,600
Nebraska	16,848,000	1,404,019	8,761,079
California	43,781,000	3,291,820	30,646,844
Oregon	13,689,000	845,000	9,582,300
Nevada	335,000	18,306	251,250
Colorado	1,851,000	87,300	1,332,547
Arizona	337,000	25,930	252,818
Dakota	41,652,000	4,431,034	24,991,032
Idaho	1,449,000	81,427	1,116,039
Montana	1,539,000	85,000	1,153,875
New Mexico	1,096,000	86,295	800,041
Utah	1,880,000	122,878	1,410,025
Washington	6,856,000	415,500	4,799,025
Total	490,560,000	38,123,859	342,491,707

Wheat is grown in every State in the Union, though only in occasional patches in Florida and Louisiana, and only to a very limited extent throughout the cotton States. A part of northern central Texas, and Tennessee east of the river which gives its name to the State, are the districts in which it is most extensively grown in the South. The State having the largest distribution of wheat acreage is Indiana, which had 121 acres to each thousand of superficial area in 1888; Ohio stood second, with 102 acres; and Maryland third, with 88 acres. Dakota had only 41 acres per thousand, and California 24. There were sixteen States having from 1 to 10 acres only.

The State making the highest yield for ten years past is Colorado, with an average of 19.6 bushels per acre. Other Rocky Mountain districts approach this average; several of the New England States come next; Michigan is the twelfth in rank; Illinois eighteenth; and California twenty-fifth. The averages of ten years past, from 1879 to 1888, are as follows:

States.	Average yield.	States.	Average yield.	States.	Average yield.	States.	Average yield.
Colorado	19.6	New York	15.3	California	13.0	Arkansas	7.2
Wyoming	18.0	Ohio	14.6	Minnesota	12.6	Georgia	6.5
Montana	17.8	Indiana	14.1	Maryland	12.4	Tennessee	6.4
Nevada	17.8	New Hampshire	13.9	Wisconsin	12.0	Alabama	6.2
Utah	17.8	Arizona	13.7	Delaware	11.7	North Carolina	6.2
Idaho	17.1	Illinois	13.7	Missouri	11.7	South Carolina	6.0
Massachusetts	16.9	Maine	13.7	Nebraska	11.3	Mississippi	5.8
Connecticut	16.7	Dakota	13.6	West Virginia	10.6	Florida	4.7
Vermont	16.7	New Mexico	13.5	Iowa	10.3		
Washington	16.7	Kansas	13.3	Texas	10.2	Average	12.3
Oregon	16.6	New Jersey	13.2	Kentucky	9.5		
Michigan	15.9	Pennsylvania	13.1	Virginia	8.1		

The progress of wheat-growing westward, which has attracted so much attention, has not even yet been stayed. Forty years ago more than half of the crop was produced east of the Alleghany Mountains, and only one-twentieth west of the Mississippi. In ten years, in 1859, the proportion of the original States had fallen below one-

third, and that of the trans-Mississippi region risen to one-seventh. The East dropped to one-fifth in another ten years, and to about one-seventh in 1879, where it now rests. Meantime the country beyond the Mississippi grew almost one-third of the product in 1869, nearly four-tenths in 1879, and one-half in 1889. The central line of wheat-growing is now on the western bank of the Mississippi. The central belt produced more than half before 1859, fell a little below half in 1869 and 1879, and to scarcely three-eighths in 1889. The probability is that the center of wheat-growing has not yet reached its western limit. As cultivation progresses through the mountain region the crop will for a time be prominent though not paramount, as in some of the areas of recent settlement, and afterwards will decline relatively as crop diversification ensues, though the aggregate product may still be larger. In the course of time there will be increase of wheat-growing east of the Mississippi, as a necessity of farm rotation and for the needs of an enlarged population, with a larger rate of yield than at present.

The wheat supply, in proportion to population, was just about twice as much in 1879 as in 1849, as returned by the census. It may be that the supply of 1879 and of 1884, which was 9.16 bushels per head, will never again be equaled. Ten years ago three-eighths of the production was exported, and one-third for a period of six years. There is little probability that so large a proportion will ever again be exported, and a small contingency that so much will ever again be wanted abroad. The average exportation of the past nine years is 128,525,180 bushels, which is less by 57,796,334 bushels than the large foreign shipments of 1880–'81. At the same time our domestic consumption has increased by about the same figure that marks the reduction in exportation.

The requirement for consumption and seed from the crop of 1889 will probably not exceed 355,000,000 bushels, leaving 135,000,000 bushels available for exportation, a quantity slightly in excess of the average exports since 1880.

The following table makes the area and product of 1880 and 1889 nearly equal, with a heavy decline in value, the cause of which is not left in doubt, viz, a decline in foreign demand. The rate of yield for the decade is 12.1 bushels per acre; of the previous decade, 12.4 bushels. The decline in value makes a reduction in gross returns per acre from $13 to $9.97.

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	498,540,868	37,986,717	$474,201,850	95.1	13.1	$12.48
1881	383,280,090	37,709,020	456,880,427	119.3	10.2	12.12
1882	504,185,470	37,067,194	444,602,125	88.2	13.6	11.99
1883	421,086,160	36,455,593	383,649,272	91.0	11.6	10.52
1884	512,765,000	39,475,885	330,862,260	64.5	13.0	8.38
1885	357,112,000	34,189,246	275,320,390	77.1	10.4	8.05
1886	457,218,000	36,806,184	314,226,020	68.7	12.4	8.54
1887	456,329,000	37,641,783	310,612,960	68.1	12.1	8.25
1888	415,868,000	37,336,138	385,248,030	92.6	11.1	10.32
1889	490,560,000	38,123,859	342,491,707	69.8	12.9	8.98
Total	4,496,953,588	372,791,619	3,718,095,041	....	....	....
Annual average	449,695,359	37,279,162	371,809,504	82.7	12.1	9.97
Annual average for preceding ten years	312,152,728	25,187,414	327,407,258	104.9	12.4	13.00

The distribution of wheat since 1879 for domestic bread, for seed, and for the foreign demand accounts for the production estimated. The exports are from the records of exportation; the seed is on a basis of 1⅜ bushels per acre for winter wheat and 1.5 for spring wheat; and the rate of consumption is calculated as 4⅔ bushels per head of population. These bases were fixed after thorough and patient investigation, and no reason has ever been assigned for their change. The several crops vary in size and the exports are extremely variable, so that the distribution of any one year can not be expected to coincide with the production of the same year; yet after nine years of estimates, made in advance of the records of exports, the averages of production and distribution vary less than 2,000,000 bushels. The average production is 445,154,843 bushels, and the distribution is 446,843,153 bushels.

The distribution has been larger than the production in five years of the nine; in 1885, by about 60,000,000 bushels, and in 1881, by about 29,000,000. On the contrary, in 1882, the year of the largest production of wheat in the United States the distribution fell short of the season's production about 48,000,000 bushels. These differences are fully accounted for by the record of visible supplies on the 1st of July of each year, as collected under commercial auspices, and the returns of wheat in the hands of the farmers as made by correspondents of the Department of Agriculture in March.

The table is as follows:

Year.	Production.	For food.	For seed.	Exportation.	Total distribution.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1880	498,549,868	242,086,655	56,563,530	186,321,514	484,971,699
1881	383,280,090	235,249,812	55,215,573	121,892,389	412,357,774
1882	504,185,470	255,500,000	52,770,312	147,811,316	456,081,628
1883	421,086,160	259,500,000	54,083,389	111,534,182	425,717,571
1884	512,765,000	265,000,000	55,266,239	132,570,367	452,836,606
1885	357,112,000	271,000,000	51,474,906	94,565,794	417,040,700
1886	457,218,000	277,000,000	51,528,658	153,804,970	482,333,628
1887	456,329,000	283,000,000	53,009,982	119,625,344	455,635,326
1888	415,868,000	292,000,000	54,012,702	88,600,743	434,613,445
Total	4,006,393,588	2,380,336,467	484,525,291	1,156,726,619	4,021,588,377
Average	445,154,843	264,481,830	53,836,143	128,525,180	446,843,153

Including the heavy exportation of 1880 in grain and flour, the proportion of wheat exported in nine years reaches nearly 29 per cent., furnishing about one-half of the requirements of the world's market for deficiencies in the bread supply of the nations.

OATS.

The increase in the acreage of oats has been one of the most noticeable tendencies of crop distribution. The increment has been relatively much greater than that of any other cereal crop, or of any prominent crop whatever. The average area for the decade ended in 1879 was 11,076,822 acres; the average acreage from 1880 to 1889, inclusive, 21,996,376, an increment of 99 per cent. The recent seasons have not been so favorable, on account mainly of drought, and the average yields of the two periods, 314,441,178 and 584,395,839, respectively, do not make so large an increase, yet it is much more than the advance in population, showing a largely increased use of oats,

greatly to the improvement of the ration for horses, supplementing corn as feed for farm animals and wheat as food for men.

In the distribution of oats, on the basis of superficial area, Illinois occupies the first rank, having 107 acres to every thousand in 1888; Iowa has the second place, with 72 acres; and Indiana comes next, with 47 acres, followed closely by New York and Pennsylvania. No less than nineteen States have less than 10 acres in every thousand.

The following table gives the average of ten years' estimates of yield per acre, 1879 to 1888, and shows the relative rank of each in production:

States.	Average yield.	States.	Average yield.	States.	Average yield.	States,	Average yield.
Washington	37.3	Wisconsin	31.2	Maine	28.1	Arkansas	17.2
Minnesota	34.3	Massachusetts	30.4	Indiana	27.7	Tennessee	14.2
Montana	34.2	Nebraska	30.4	Rhode Island	27.7	Louisiana	13.0
New Hampshire	33.5	Nevada	30.4	Missouri	26.4	Virginia	12.0
Illinois	33.4	Wyoming	30.2	Utah	26.3	Alabama	11.4
Vermont	33.2	New York	29.4	Arizona	25.0	Mississippi	11.2
Iowa	33.0	Kansas	29.3	Texas	24.3	South Carolina	10.6
Idaho	33.1	Oregon	29.1	New Mexico	22.6	Georgia	10.4
Michigan	32.0	Pennsylvania	29.0	Delaware	22.1	Florida	10.3
Colorado	31.7	California	28.2	Maryland	20.7	North Carolina	10.1
Dakota	31.5	Connecticut	28.2	West Virginia	19.1		
Ohio	31.2	New Jersey	28.2	Kentucky	18.8	Average	27.0

The first statement of the crop of 1889 made the general condition 93.8, the State averages being higher west of the Mississippi River than in the Ohio Valley. The month of June was favorable, the weather cooler than usual, with ample moisture, placing the July average at 94.1, notwithstanding drought in Dakota and in less degree in parts of the other States, which reduced the local averages of certain States. The condition on the 1st of August, or at the harvest where the crop had been previously cut, was 92.3. A little improvement had taken place in the Ohio Valley, and slight decline in the States of the Atlantic coast, in Dakota, and elsewhere. There was a heavy growth of straw in the districts of heavy rain-fall, with some lodging and rust. The harvest season was wet west of the Mississippi, and some damage accrued from rust.

The estimates of the crop of 1889 are as follows:

States and Territories.	Bushels.	Acres.	Value.
Maine	2,764,000	94,025	$1,022,804
New Hampshire	956,000	31,359	363,451
Vermont	3,324,000	105,536	1,196,778
Massachusetts	646,000	23,750	245,480
Rhode Island	170,000	6,417	64,619
Connecticut	1,009,000	39,413	373,320
New York	26,009,000	1,384,967	11,522,925
New Jersey	3,408,000	144,425	1,158,866
Pennsylvania	34,504,000	1,316,932	10,351,085
Delaware	420,000	22,931	121,695
Maryland	2,203,000	117,786	660,779
Virginia	9,166,000	678,[illegible]	3,116,463
North Carolina	6,941,000	680,477	3,053,981
South Carolina	4,129,000	393,226	1,961,859
Georgia	6,874,000	624,874	3,436,807
Florida	568,000	54,081	295,283
Alabama	3,970,000	417,880	1,905,533
Mississippi	3,656,000	358,408	1,718,208
Louisiana	396,000	42,110	174,167
Texas	14,808,000	652,320	4,886,529

States and Territories.	Bushels.	Acres.	Value.
Arkansas	4,348,000	293,831	$1,745,356
Tennessee	8,179,000	711,207	2,453,664
West Virginia	2,520,000	146,502	781,149
Kentucky	9,456,000	511,156	2,553,224
Ohio	36,615,000	1,169,823	8,421,556
Michigan	30,469,000	931,770	7,617,220
Indiana	27,317,000	968,688	5,736,570
Illinois	145,364,000	3,876,380	27,619,208
Wisconsin	53,697,000	1,527,437	10,012,350
Minnesota	53,128,000	1,562,588	10,625,598
Iowa	99,459,000	2,739,931	15,913,519
Missouri	36,384,000	1,426,839	6,549,191
Kansas	37,529,000	1,416,178	5,629,308
Nebraska	29,963,000	1,085,628	4,494,500
California	1,890,000	75,973	854,696
Oregon	5,432,000	211,371	2,118,572
Colorado	3,129,000	97,791	1,251,725
Dakota	23,290,000	1,245,428	6,288,166
Idaho	1,000,000	35,725	450,135
Montana	2,578,000	85,938	1,134,382
New Mexico	340,000	16,168	142,602
Utah	916,000	36,658	412,403
Washington	3,082,000	99,421	1,325,282
Total	751,515,000	27,462,316	171,781,008

The rate of yield is estimated at 27.4 bushels per acre, which exceeds the average of ten years 26.6 bushels. The average of the previous decennial period was 28.4 bushels. The value per bushel, 22.9 cents, is the lowest ever reported. The decade average is 30.9 cents against 35.3 cents for the previous period. This helped to reduce the average value per acre from $10.03 to $8.22.

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	417,885,380	16,187,977	$150,243,565	36.0	25.8	$9.28
1881	416,481,000	16,831,600	193,198,970	46.4	24.7	11.48
1882	488,250,610	18,494,691	182,978,022	37.5	26.4	9.64
1883	571,302,400	20,324,962	187,040,264	33.0	28.1	9.27
1884	583,628,000	21,300,917	161,528,470	28.0	27.4	7.58
1885	629,409,000	22,783,630	179,631,860	28.5	27.6	7.88
1886	624,134,000	23,658,474	186,137,930	29.8	26.4	7.87
1887	659,618,000	25,920,906	200,699,790	30.4	25.4	7.74
1888	701,735,000	26,998,282	195,424,240	27.8	26.0	7.24
1889	751,515,000	27,462,316	171,781,008	22.9	27.4	6.26
Total	5,843,958,390	219,963,755	1,808,664,119			
Annual average	584,395,839	21,996,376	180,866,412	30.9	26.6	8.22
Annual average for preceding ten years	314,441,178	11,076,822	111,075,223	35.3	28.4	10.03

BARLEY.

An average breadth of barley was seeded in 1889, and a medium crop was matured, between 21 and 22 bushels per acre, on a area approximating 3,000,000 acres. Another half million acres would scarcely supply the consumption. While the price of wheat is reduced by surplus production the farmers of the higher latitudes could add $8,000,000 at least to the gross proceeds of their industry by supplying the home demand. Six-sevenths of the crop is grown in seven States, viz: California, Minnesota, Dakota, Nebraska, Iowa,

Wisconsin, and New York. More than one-fourth is usually produced in California alone. The estimates by States are not complete for 1889, as this report goes to the press, but the record of nine years since 1879 is as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	45,165,346	1,843,329	$30,090,742	66.6	24.5	$16.32
1881	41,161,330	1,967,510	33,862,513	82.3	20.9	17.21
1882	48,953,926	2,272,103	30,768,015	62.8	21.5	13.54
1883	50,136,097	2,379,009	29,420,423	58.7	21.1	12.38
1884	61,203,000	2,608,818	29,779,170	48.7	23.5	11.41
1885	58,360,000	2,729,359	32,867,696	56.3	21.4	12.04
1886	59,428,000	2,652,957	31,840,510	53.6	22.4	12.00
1887	56,812,000	2,901,973	29,464,390	51.9	19.6	10.15
1888	63,884,000	2,996,382	37,672,032	59.0	21.3	12.57
Total	485,103,699	22,351,430	285,765,491			
Annual average	53,900,411	2,483,491	31,751,721	58.9	21.7	12.79
Annual average for preceding ten years	33,704,652	1,529,357	24,885,503	73.8	22.0	16.27

The imports of barley are constantly increasing, though it was worth $12.79 per acre for the past decade, while wheat was worth only $9.97 per acre, corn $9.48, and rye $7.39. The following table shows how much money has gone out of the country which the farmers of Michigan and the Northwest might have appropriated towards paying mortgages or buying more land:

Years.	Bushels.	Value.	Years.	Bushels.	Value.
1870	6,727,597	$4,759,563	1882	12,182,722	$10,866,628
1871	4,866,700	3,678,810	1883	10,050,687	7,737,984
1872	5,565,591	3,403,607	1884	8,596,122	5,922,144
1873	4,244,751	2,962,981	1885	9,986,507	6,522,092
1874	4,891,189	5,801,653	1886	10,197,115	7,177,887
1875	6,255,063	6,297,738	1887	10,355,594	6,173,208
1876	10,285,957	7,887,886	1888	10,831,461	8,076,082
1877	6,702,965	5,099,326	1889	11,368,414	7,723,838
1878	6,764,228	4,105,748			
1879	5,720,979	5,402,680	Total	162,257,516	120,829,901
1880	7,135,258	4,537,921			
1881	9,528,616	6,692,125	Annual average	8,112,876	6,041,495

RYE.

Half as much rye was grown thirty years ago as at the present time. It is strange that so small a consumption is required in view of the fact that so large a portion of our population has been derived from the rye-eating nations of Europe. The census aggregates of rye are 14,188,813 bushels in 1849, 21,101,380 in 1859, 16,918,795 in 1869, and 19,831,595 in 1879. The difficulty of estimating accurately the changes annually occurring is especially great as to these minor crops, which are scattered and unequally distributed. Under such limitations the following annual estimates are recorded:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	24,540,829	1,767,619	$18,564,560	75.6	13.9	$10.50
1881	20,704,950	1,789,100	19,327,415	93.3	11.6	10.80
1882	29,960,037	2,227,894	18,439,194	61.5	13.4	8.28
1883	28,058,582	2,314,754	16,300,503	58.0	12.1	7.04
1884	28,640,000	2,343,963	14,857,040	52.0	12.2	6.34
1885	21,756,000	2,129,301	12,594,820	57.9	10.2	5.92
1886	24,489,000	2,129,918	13,181,330	53.8	11.5	6.19
1887	20,693,000	2,053,447	11,283,140	54.5	10.1	5.49
1888	28,415,000	2,364,805	16,721,869	58.8	12.0	7.07
Total	227,257,398	19,120,801	141,269,871			
Annual average	25,250,822	2,124,533	15,696,652	62.2	11.9	7.39
Annual average for preceding ten years	18,460,985	1,305,061	12,945,136	70.1	14.1	9.92

BUCKWHEAT.

This crop is the smallest of the cereals, and has always been produced mainly in New York and Pennsylvania. At one time Ohio was a factor of some importance in its production. In northern latitudes it sometimes supplements other grains which have not had their usual distribution, or have been reduced in breadth by some vicissitude of the season. Like rye, it had a large development between 1850 and 1860, doubled in quantity, the product being 17,571,818 bushels for 1859. The estimates of recent years are:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	14,617,535	822,802	$8,682,488	59.4	17.7	$10.55
1881	9,486,200	828,815	8,205,705	86.5	11.4	9.90
1882	11,019,353	817,112	8,038,862	72.9	13.1	9.48
1883	7,668,954	857,349	6,303,980	82.2	8.9	7.35
1884	11,116,000	879,403	6,549,020	59.0	12.6	7.45
1885	12,626,000	914,394	7,057,363	55.9	13.8	7.72
1886	11,869,000	917,915	6,465,120	54.5	12.9	7.04
1887	10,844,000	910,506	6,122,320	56.5	11.9	6.72
1888	12,050,000	912,630	7,627,647	63.3	13.2	8.36
Total	101,297,042	7,890,926	65,052,505			
Annual average	11,255,227	876,770	7,228,056	64.2	12.8	8.24
Annual average for preceding ten years	9,747,272	551,104	6,972,974	71.5	17.7	12.65

ALL CEREALS.

This consolidation of the cereals includes only corn, wheat, oats, rye, barley, and buckwheat. The increase over the previous decennial period is very heavy—much beyond the increase of population—being nearly 50 per cent. If we should include the aggregate for 1889, a year of larger production than 1888, the ratio of advance would go still higher. The average supply for the period is thus about 50 bushels per capita, and that of the present year will be nearly 52 bushels.

Calendar years.	Total production.	Total area of crops.	Total value of crops.
	Bushels.	*Acres.*	
1880	2,718,193,501	120,926,286	$1,361,497,704
1881	2,066,029,570	123,388,070	1,470,957,200
1882	2,699,394,496	126,568,539	1,468,693,393
1883	2,629,319,088	130,633,556	1,280,765,927
1884	2,992,880,000	136,292,766	1,184,311,520
1885	3,015,439,000	135,876,080	1,143,146,759
1886	2,842,579,000	141,859,656	1,162,161,910
1887	2,660,457,000	141,821,315	1,204,289,370
1888	3,209,742,000	146,281,000	1,320,255,398
Total	24,834,033,655	1,203,647,268	11,596,079,181
Annual average	2,759,337,073	133,738,585	1,288,453,242
Annual average for preceding ten years	1,872,993,769	83,391,089	987,857,142

TOBACCO.

The production of tobacco fluctuates from year to year. The difference is in the rate of yield rather than in acreage. There have sometimes been efforts, however, to reduce the area to relieve a glut of surplus product and raise prices, which have had some influence in production. This variation in rate of yield makes it difficult to estimate approximately the annual production. A still more serious difficulty is found in the conservatism which involuntarily underestimates a taxed product. This was worse when the tobacco tax was high and the prejudice against the tax was stronger than it is at present. Still it is a source of error in local estimates for which allowance must be made in revision or the aggregate will prove ridiculously inadequate to account for the recorded distribution. The Statistician, in his desire to avoid a possible injustice to growers in the consolidation of local estimates, is liable to leave the aggregates too low, scarcely sufficient to cover the subsequent figures of consumption and exportation. The following are the estimates of area, product, and value, since 1879, except that the crop of 1889 had not been fully determined at the date of preparation of this report:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per pound.	Average yield per acre.	Average value per acre.
	Pounds.	*Acres.*		*Cents.*	*Pounds.*	
1880	460,000,000	610,000	$39,100,000	8.5	754.1	$64.10
1881	450,880,014	646,239	43,372,000	9.6	697.7	67.11
1882	513,077,558	671,522	43,189,951	8.4	764.1	64.32
1883	451,545,641	638,739	40,455,362	9.0	706.9	63.34
1884	541,504,000	724,668	44,160,151	8.2	747.2	60.94
1885	562,736,000	752,520	43,265,598	7.7	747.8	57.49
1886	532,537,000	750,210	39,468,218	7.4	709.9	52.61
1887	386,240,000	598,620	40,977,259	10.6	645.2	68.45
1888	565,795,000	747,326	43,666,665	7.7	757.1	58.43
Total	4,464,315,213	6,139,844	377,655,204			
Annual average	496,035,024	682,205	41,961,689	8.5	727.1	61.51
Average for preceding ten years	464,920,000	629,944	39,770,600	8.6	738.0	63.13

The crop of 1889 was smaller than that of 1888, the rate of yield only medium and the quality relatively inferior, yet the supply will be ample for the home and foreign demand. The influence of Sumatra wrapper importations is severely felt by Northern growers of cigar leaf, tending to reduce area and discourage effort for the development of this branch of tobacco growing.

The following table shows the distribution of tobacco in comparison with estimated production:

Years.	Product.	Domestic manufacture.	Exported.	Distribution.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1880	460,000,000	198,321,553	225,737,776	424,059,329
1881	450,880,014	227,762,943	218,244,205	446,007,148
1882	513,077,558	221,865,097	225,525,793	447,390,890
1883	451,545,641	251,183,209	239,584,814	490,768,023
1884	541,504,000	230,219,463	195,652,539	425,872,002
1885	562,736,000	255,397,369	278,139,130	533,536,499
1886	532,537,000	262,397,208	304,048,818	566,446,026
1887	386,240,000	269,617,615	247,991,111	517,608,726
1888	565,795,000	252,703,921	204,184,021	456,887,942
Total	4,464,315,213	2,169,468,378	2,139,108,207	4,308,576,585
Average	496,035,024	241,052,042	237,678,690	478,730,732

The quantity of domestic leaf exported in the last nine calendar years amounts to 2,139,108,207 pounds, the quantity manufactured to 2,169,468,378 pounds, or together 4,308,576,585 pounds, while the estimated production of the same period amounts to 4,464,315,213 pounds. The production therefore averages 17,304,292 pounds more per annum than the distribution. There is a small quantity unreported that goes into consumption from the hands of growers that does not pay the tax, which would make more than this difference. This proves that the charge of overestimates is unfounded, and that the liability to error of ten to twenty years ago has been eliminated by more accurate reporting and more thorough revision in consolidation.

It will be seen that the distribution of 1887 amounted to 517,608,726 pounds, while the estimate was 386,240,000 pounds, requiring 131,368,-726 pounds to be taken from the large surplus which had then accumulated. In that year there was a preconcerted effort to reduce the area, a result almost impossible to accomplish by mutual agreement of growers. In this instance bad condition of the seed beds in spring and drought at the time of planting aided the effort of holders of old stocks to induce growers to restrict acreage.

In Kentucky great dissatisfaction was expressed at the estimate of 22 per cent. reduction of area on the 1st of July, the dealers claiming a reduction of about 58 per cent. in area alone. The discrepancy was less than appeared. There are two elements of reduction, area and condition; in this case area 78, condition 77 ($78 \times 77 = 60$ nearly), showing so early in the season the prospect of a reduction of 40 per cent., a figure which was increased to 44 per cent. by later reduction of condition. The dealers counted loss of area and unthrifty condition of what remained together, and improperly called it all reduction of area. The result proved the Department figures much nearer right than those of the persons challenging their correctness. The estimated product was 115,896,000 pounds, while the Kentucky assessors returned 117,282,876 pounds. Instead of being too high, this estimate was evidently too low, as some assessors failed to report. The State report showed a product of 55 per cent. of that of the previous year, more than half a crop, whereas 42 per cent. of area, with reduced condition, would have barely made a third of a crop. The Department's reported area in July and the November condition together made 52 per cent. of the previous crop, almost exactly what is shown by the State returns. This outcome was naturally expected, as it would be contrary to human nature if millions of dollars

held in the product on speculation should not distort the judgment of holders. As a necessary fact, many fortunes were made during that year by owners of this immense surplus.

POTATOES.

The total production of potatoes has increased in ten years, as estimated, somewhat more than one-fourth. The average value per bushel, as compared with the preceding period between 1870 and 1880, is 50.4 cents against 56.2, the yield per acre 76.3 instead of 87.7, and the value of product per acre has declined from $49.31 to $38.41. Though the average yield of the previous period is not sustained, very large individual yields are reported. Perhaps the largest rate of production ever made is the result, during 1889, of contests for premiums on the largest yields.

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	167,659,570	1,842,510	$81,062,214	48.3	91.0	$44.00
1881	109,145,494	2,041,670	99,291,341	90.9	53.5	48.63
1882	170,972,508	2,171,636	95,304,844	55.7	78.7	43.89
1883	208,164,425	2,289,275	87,849,991	42.2	91.0	38.37
1884	190,642,000	2,220,980	75,524,290	39.6	85.8	34.00
1885	175,029,000	2,265,823	78,153,403	44.7	77.2	34.49
1886	168,051,000	2,287,136	78,441,940	46.7	73.5	34.30
1887	134,103,000	2,357,322	91,506,740	68.2	56.9	38.82
1888	202,365,000	2,533,280	81,413,589	40.2	79.9	32.14
Total	1,526,131,997	20,009,632	768,548,352			
Annual average	169,570,222	2,223,292	85,394,261	50.4	76.3	38.41
Annual average for preceding ten years	132,837,175	1,514,045	74,653,771	56.2	87.7	49.31

HAY.

There has been a large increase in hay production during the last ten years. It has occurred in the South, where little attention was formerly paid to hay-making; where grass, in fact, was under the ban of rural public opinion. A great change has taken place there, and many growers realize that grass is the mainstay of all agriculture, not excepting that of the cotton States. Very large increase of hay production has also occurred in the Rocky Mountain region. Few ranches now undertake to winter stock without a reserve of hay against storms or frost and ice. The spring-wheat States have taken the lead in increase of hay in the Western States for beef-making and dairying in place of exclusive wheat growing. The table following gives the comparative statistics of hay in recent years:

Calendar years.	Total production.	Total area of crop.	Total value of crop.	Average value per ton.	Average yield per acre.	Average value per acre.
	Tons.	*Acres.*			*Tons.*	
1880	31,925,233	25,863,955	$371,811,084	$11.65	1.23	$14.38
1881	35,135,064	30,888,700	415,131,366	11.82	1.14	13.43
1882	38,138,049	32,339,585	371,170,326	9.73	1.18	11.48
1883	46,864,009	35,515,948	383,834,451	8.19	1.32	10.81
1884	48,470,460	38,571,593	396,139,309	8.17	1.26	10.27
1885	44,731,550	39,849,701	389,752,873	8.71	1.12	9.78
1886	41,796,499	36,501,688	353,437,699	8.46	1.15	9.68
1887	41,454,458	37,664,739	413,440,283	9.97	1.10	10.98
1888	46,643,094	38,591,903	408,499,565	8.76	1.21	10.59
Total	375,158,416	315,787,812	3,503,216,956			
Annual average	41,684,268	35,087,535	389,246,328	9.34	1.19	11.09
Annual average for preceding ten years	28,526,750	23,142,841	323,935,991	11.36	1.23	14.00

CROP ESTIMATES FOR 1888.

Table showing the product of the cereals, potatoes, tobacco, hay, and cotton of the several States named, the yield per acre, the total acreage, the average price in each State, and the value of each crop for 1888.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Maine	Indian corn .... bushels..	596,000	19.3	30,878	$0.75	$447,000
	Wheat .... do....	589,000	14.5	40,644	1.20	706,800
	Rye .... do....	28,000	12.1	2,311	.89	24,959
	Oats .... do....	2,656,000	27.4	96,933	.43	1,142,080
	Barley .... do....	240,000	21.2	11,318	.69	165,560
	Buckwheat .... do....	220,000	10.3	21,343	.58	127,503
	Potatoes .... do....	7,882,000	110	71,651	.46	3,625,541
	Hay .... tons..	1,292,791	.98	1,319,174	10.75	13,897,503
	Total	....	....	1,594,252	....	20,136,946
New Hampshire	Indian corn .... bushels..	846,000	22.6	37,421	.72	609,120
	Wheat .... do....	152,000	14.6	10,380	1.20	182,400
	Rye .... do....	33,000	11.5	2,861	.87	28,701
	Oats .... do....	1,033,000	30.3	34,086	.44	454,520
	Barley .... do....	81,000	21.4	3,780	.68	54,750
	Buckwheat .... do....	56,000	11.5	4,880	.57	31,988
	Potatoes .... do....	3,072,000	102	30,114	.47	1,443,665
	Hay .... tons..	644,729	.95	678,662	10.50	6,769,655
	Total	....	....	802,184	....	9,574,799
Vermont	Indian corn .... bushels..	1,494,000	24.3	61,470	.66	986,040
	Wheat .... do....	346,000	16.7	20,710	1.18	408,280
	Rye .... do....	75,000	12.9	5,797	.74	55,767
	Oats .... do....	3,536,000	32.5	108,800	.41	1,449,760
	Barley .... do....	257,000	22.2	11,594	.66	169,875
	Buckwheat .... do....	240,000	13.3	18,041	.56	134,369
	Potatoes .... do....	3,876,000	100	38,761	.42	1,627,962
	Hay .... tons..	1,038,303	1.00	1,038,303	9.40	9,760,048
	Total	....	....	1,303,476	....	14,592,101
Massachusetts	Indian corn .... bushels..	1,788,000	30.1	59,397	.68	1,215,840
	Rye .... do....	213,000	11.3	18,840	.80	170,314
	Oats .... do....	705,000	28.2	25,000	.45	317,250
	Barley .... do....	69,000	21.0	3,280	.74	50,971
	Buckwheat .... do....	65,000	11.9	5,441	.70	45,704
	Potatoes .... do....	3,632,000	101	35,964	.55	1,997,800
	Tobacco .... pounds..	3,893,000	1,580	2,464	.13	486,640
	Hay .... tons..	674,365	1.05	642,252	15.75	10,621,249
	Total	....	....	792,638	....	14,905,768
Rhode Island	Indian corn .... bushels..	382,000	30.4	12,558	.70	267,400
	Rye .... do....	15,000	11.7	1,278	.78	11,655
	Oats .... do....	174,000	27.4	6,353	.44	76,560
	Barley .... do....	20,000	23.6	848	.75	14,946
	Potatoes .... do....	668,000	97	6,889	.55	367,528
	Hay .... tons..	104,829	1.00	104,829	15.80	1,656,298
	Total	....	....	132,755	....	2,394,387
Connecticut	Indian corn .... bushels..	1,778,000	31.2	56,977	.65	1,155,700
	Wheat .... do....	32,000	14.9	2,149	1.20	38,400
	Rye .... do....	348,000	12.2	28,500	.74	257,298
	Oats .... do....	1,055,000	26.5	39,811	.43	453,650
	Barley .... do....	14,000	21.9	638	.71	9,876
	Buckwheat .... do....	134,000	12.2	10,974	.65	87,024
	Potatoes .... do....	2,677,000	80	33,459	.53	1,418,662
	Tobacco .... pounds..	9,603,000	1,565	6,136	.13	1,248,369
	Hay .... tons..	574,419	1.02	563,156	14.70	8,443,959
	Total	....	....	741,800	....	13,112,938
New York	Indian corn .... bushels..	22,870,000	32.4	705,859	.58	13,264,600
	Wheat .... do....	9,309,000	14.1	660,214	1.10	10,239,900
	Rye .... do....	2,724,000	11.5	236,851	.63	1,715,986
	Oats .... do....	40,570,000	29.0	1,398,957	.37	15,010,900
	Barley .... do....	7,418,000	21.6	343,428	.70	5,192,632
	Buckwheat .... do....	4,514,000	14.5	311,310	.62	2,798,677
	Potatoes .... do....	29,688,000	80	371,105	.38	11,281,592
	Tobacco .... pounds..	6,488,000	1,050	6,179	.12	778,554
	Hay .... tons..	5,426,757	1.10	4,933,415	11.25	61,051,016
	Total	....	....	8,967,318	....	121,333,857
New Jersey	Indian corn .... bushels..	11,351,000	32.4	350,335	.53	6,016,030
	Wheat .... do....	1,785,000	12.6	141,652	1.10	1,963,500
	Rye .... do....	1,098,000	10.4	105,588	.63	691,812
	Oats .... do....	3,688,000	26.3	140,218	.36	1,327,680
	Buckwheat .... do....	464,000	13.0	35,723	.71	329,723
	Potatoes .... do....	3,599,000	83	43,366	.50	1,799,689
	Hay .... tons..	586,386	1.20	488,655	12.75	7,476,422
	Total	....	....	1,305,537	....	19,604,856

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Pennsylvania	Indian corn ...... bushels	45,414,000	32.5	1,397,350	$0.50	$22,707,000
	Wheat ...... do	18,802,000	13.5	1,392,728	1.07	20,118,140
	Rye ...... do	4,458,000	11.2	398,076	.62	2,764,240
	Oats ...... do	35,251,000	26.5	1,330,234	.34	11,985,340
	Barley ...... do	458,000	17.0	26,951	.65	297,809
	Buckwheat ...... do	3,881,000	14.0	277,189	.65	2,522,420
	Potatoes ...... do	16,305,000	80	203,810	.40	6,521,920
	Tobacco ...... pounds	24,180,000	1,240	19,500	.11	2,587,260
	Hay ...... tons	2,997,068	1.10	2,724,607	11.00	32,967,748
	Total	......	......	7,770,445	......	102,471,877
Delaware	Indian corn ...... bushels	3,844,000	17.4	220,927	.44	1,691,360
	Wheat ...... do	1,194,000	12.6	94,790	1.00	1,194,000
	Rye ...... do	8,000	9.3	857	.58	4,628
	Oats ...... do	450,000	20.6	21,839	.35	157,500
	Potatoes ...... do	317,000	75	4,224	.48	152,064
	Hay ...... tons	66,363	1.18	56,240	13.00	862,719
	Total	......	......	398,877	......	4,062,271
Maryland	Indian corn ...... bushels	17,553,000	23.7	740,645	.45	7,898,850
	Wheat ...... do	7,634,000	13.7	557,208	1.00	7,634,000
	Rye ...... do	326,000	10.7	30,443	.60	195,444
	Oats ...... do	2,296,000	19.3	118,976	.33	757,680
	Buckwheat ...... do	143,000	12.5	11,439	.67	95,802
	Potatoes ...... do	1,654,000	78	21,204	.46	760,800
	Tobacco ...... pounds	14,017,000	415	33,775	.05	770,914
	Hay ...... tons	376,239	1.15	327,164	12.76	4,800,810
	Total	......	......	1,840,854	......	22,914,300
Virginia	Indian corn ...... bushels	34,745,000	16.3	2,131,595	.49	17,025,050
	Wheat ...... do	5,172,000	8.3	623,121	1.00	5,172,000
	Rye ...... do	375,000	7.3	51,322	.61	228,537
	Oats ...... do	8,108,000	12.3	659,192	.36	2,918,880
	Barley ...... do	18,000	14.9	1,209	.64	11,606
	Buckwheat ...... do	242,000	10.0	24,187	.60	145,122
	Potatoes ...... do	2,346,000	65	36,098	.50	1,173,185
	Tobacco ...... pounds	64,034,000	504	127,052	.06	3,842,052
	Hay ...... tons	387,936	1.05	369,463	13.00	5,043,168
	Cotton ...... pounds	6,649,107	157	42,351	.083	551,876
	Total	......	......	4,065,590	......	36,111,476
North Carolina	Indian corn ...... bushels	28,343,000	10.6	2,673,910	.58	16,438,940
	Wheat ...... do	3,835,000	5.4	710,268	1.05	4,026,750
	Rye ...... do	365,000	5.3	68,855	.82	299,244
	Oats ...... do	6,078,000	9.2	660,657	.46	2,795,880
	Buckwheat ...... do	69,000	10.5	6,592	.58	40,145
	Potatoes ...... do	1,377,000	63	21,856	.65	895,003
	Tobacco ...... pounds	25,755,000	451	57,107	.08	1,931,644
	Hay ...... tons	154,332	1.10	140,302	13.10	2,021,749
	Cotton ...... pounds	176,819,445	165	1,071,633	.085	15,029,653
	Total	......	......	5,411,180	......	43,479,008
South Carolina	Indian corn ...... bushels	13,715,000	8.7	1,576,388	.60	8,229,000
	Wheat ...... do	973,000	5.0	194,563	1.12	1,089,760
	Rye ...... do	44,000	5.2	8,451	.85	37,353
	Oats ...... do	3,773,000	9.5	397,198	.55	2,075,150
	Potatoes ...... do	274,000	60	4,563	.90	246,402
	Hay ...... tons	33,810	1.15	29,400	13.25	447,983
	Cotton ...... pounds	266,735,916	162	1,646,518	.085	22,672,553
	Total	......	......	3,857,081	......	34,798,201
Georgia	Indian corn ...... bushels	28,069,000	9.6	2,923,885	.60	16,841,400
	Wheat ...... do	1,910,000	5.1	374,452	1.10	2,101,000
	Rye ...... do	151,000	5.3	28,456	.90	135,735
	Oats ...... do	7,115,000	11.5	618,687	.53	3,770,950
	Potatoes ...... do	638,000	62	10,291	.90	574,238
	Hay ...... tons	47,905	1.20	39,996	13.46	646,013
	Cotton ...... pounds	463,460,556	156	2,970,901	.085	39,394,147
	Total	......	......	6,966,668	......	63,463,483

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Florida	Indian corn........bushels..	4,541,000	9.8	463,392	$0.65	$2,951,650
	Oats.....................do....	599,000	11.3	53,021	.61	365,390
	Potatoes...............do....	155,000	67	2,306	.92	142,142
	Cotton.............pounds..	30,158,840	116	259,990	.084	2,533,343
	Total....................	....	....	773,709	....	5,992,525
Alabama	Indian corn........bushels..	31,616,000	12.7	2,489,475	.55	17,388,800
	Wheat..................do....	2,186,000	5.2	420,443	1.05	2,295,300
	Rye.....................do....	31,000	5.0	6,171	.90	27,770
	Oats.....................do....	4,806,000	11.5	417,880	.48	2,306,880
	Potatoes...............do....	601,000	60	10,018	.76	456,821
	Hay......................tons..	51,383	1.25	41,106	12.40	637,149
	Cotton.............pounds..	456,278,880	160	2,851,743	.085	38,783,705
	Total....................	....	....	6,236,836	....	61,696,425
Mississippi	Indian corn........bushels..	28,422,000	14.7	1,933,477	.54	15,347,880
	Wheat..................do....	532,000	6.3	84,375	1.05	558,600
	Rye.....................do....	6,000	4.9	1,220	.89	5,368
	Oats.....................do....	4,096,000	11.2	365,722	.50	2,048,000
	Potatoes...............do....	674,000	65	10,370	.75	505,538
	Hay......................tons..	58,968	1.30	45,360	12.12	714,692
	Cotton.............pounds..	523,584,202	202	2,592,001	.086	45,028,241
	Total....................	....	....	5,032,525	....	64,208,319
Louisiana	Indian corn........bushels..	15,263,000	14.8	1,031,263	.53	8,089,390
	Oats.....................do....	495,000	12.0	41,284	.45	222,750
	Potatoes...............do....	511,000	67	7,623	.80	408,593
	Hay......................tons..	78,331	1.35	58,023	10.54	825,609
	Cotton.............pounds..	219,814,552	202	1,088,191	.086	18,904,054
	Total....................	....	....	2,226,384	....	28,450,396
Texas	Indian corn........bushels..	92,436,000	19.2	4,814,363	.41	37,898,760
	Wheat..................do....	6,066,000	10.6	572,226	1.00	6,066,000
	Rye.....................do....	57,000	7.5	7,623	.87	49,741
	Oats.....................do....	13,595,000	22.3	609,645	.32	4,350,400
	Barley..................do....	188,000	12.0	15,643	.45	84,472
	Potatoes...............do....	700,000	62	11,296	.75	525,264
	Hay......................tons..	189,795	1.25	151,836	7.72	1,465,217
	Cotton.............pounds..	806,718,542	194	4,158,343	.084	67,764,358
	Total....................	....	....	10,340,975	....	118,204,212
Arkansas	Indian corn........bushels..	41,543,000	19.5	2,130,399	.48	19,940,640
	Wheat..................do....	2,267,000	9.7	233,671	.95	2,153,650
	Rye.....................do....	45,000	7.6	5,957	.79	35,742
	Oats.....................do....	5,135,000	18.0	285,273	.42	2,156,700
	Potatoes...............do....	864,000	67	12,891	.49	423,212
	Tobacco...........pounds..	1,156,000	480	2,408	.07	80,909
	Hay......................tons..	56,235	1.25	44,988	10.40	584,844
	Cotton.............pounds..	297,450,510	210	1,416,431	.085	25,283,293
	Total....................	....	....	4,132,018	....	50,658,990
Tennessee	Indian corn........bushels..	75,665,000	20.8	3,637,762	.42	31,779,300
	Wheat..................do....	10,297,000	8.5	1,211,394	.93	9,576,210
	Rye.....................do....	293,000	7.5	39,082	.70	205,181
	Oats.....................do....	11,108,000	16.4	677,340	.36	3,998,880
	Barley..................do....	36,000	11.1	3,237	.60	21,752
	Buckwheat...........do....	44,000	8.0	5,515	.60	26,472
	Potatoes...............do....	2,407,000	60	40,113	.47	1,131,187
	Tobacco...........pounds..	45,641,000	680	67,119	.08	3,651,274
	Hay......................tons..	321,071	1.20	267,559	11.00	3,531,781
	Cotton.............pounds..	176,291,600	200	881,473	.085	14,985,041
	Total....................	....	....	6,830,594	....	68,907,078
West Virginia	Indian corn........bushels..	16,149,000	23.8	678,518	.48	7,751,520
	Wheat..................do....	2,899,000	9.5	305,199	.96	2,783,040
	Rye.....................do....	148,000	7.8	19,022	.67	99,409
	Oats.....................do....	2,495,000	17.2	145,051	.36	898,200
	Barley..................do....	13,000	22.5	578	.61	7,884
	Buckwheat...........do....	373,000	9.3	40,121	.65	242,531
	Potatoes...............do....	1,849,000	65	28,443	.46	850,446
	Tobacco...........pounds..	4,496,000	800	5,620	.08	359,680
	Hay......................tons..	397,345	1.00	397,345	11.48	4,561,521
	Total....................	....	....	1,619,897	....	17,554,231

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Kentucky	Indian corn ....bushels..	81,545,000	25.8	3,160,668	$0.34	$27,725,300
	Wheat ....do....	10,436,000	10.3	1,013,228	.96	10,018,560
	Rye ....do....	834,000	9.3	89,650	.62	516,922
	Oats..............do....	8,454,000	17.2	491,496	.33	2,789,820
	Barley ....do....	245,000	22.7	10,800	.66	161,806
	Potatoes..............do....	3,228,000	62	52,072	.51	1,646,517
	Tobacco ....pounds.	283,306,000	876	323,409	.08	21,247,971
	Hay ....tons..	345,534	1.05	329,080	12.00	4,146,408
	Total..............	....	....	5,470,403	....	68,253,304
Ohio	Indian corn........bushels..	93,018,000	32.5	2,862,080	.35	32,556,300
	Wheat..............do....	28,705,000	10.8	2,657,884	.97	27,843,850
	Rye ....do....	623,000	12.5	49,847	.58	361,391
	Oats..............do....	33,819,000	31.8	1,063,475	.28	9,469,320
	Barley..............do....	584,000	22.4	26,067	.64	373,697
	Buckwheat..............do....	144,000	12.4	11,633	.70	100,974
	Potatoes..............do....	11,925,000	80	149,059	.37	4,412,146
	Tobacco ....pounds..	35,195,000	900	39,105	.08	2,745,171
	Hay ....tons..	2,960,066	1.15	2,573,970	11.16	33,034,337
	Total..............	....	....	9,433,120	....	110,897,186
Michigan	Indian corn........bushels..	29,025,000	30.0	967,513	.42	12,190,500
	Wheat..............do....	24,028,000	14.6	1,645,762	.98	23,547,440
	Rye ....do....	279,000	12.5	22,304	.63	175,644
	Oats..............do....	26,668,000	33.2	803,250	.30	8,000,400
	Barley..............do....	967,000	22.5	42,977	.66	638,209
	Buckwheat..............do....	405,000	12.5	32,394	.55	222,709
	Potatoes..............do....	8,611,000	72	119,599	.33	2,841,672
	Hay ....tons..	1,545,317	1.10	1,404,834	11.20	17,307,550
	Total..............	....	....	5,038,633	....	64,924,124
Indiana	Indian corn........bushels..	125,478,000	34.8	3,605,694	.31	38,898,180
	Wheat..............do....	28,879,000	10.4	2,774,062	.94	27,206,260
	Rye ....do....	468,000	12.3	38,037	.56	261,999
	Oats..............do....	28,522,000	26.5	1,076,320	.26	7,415,720
	Barley..............do....	406,000	21.7	18,713	.63	255,825
	Buckwheat..............do....	90,000	11.4	7,896	.70	63,010
	Potatoes..............do....	5,749,000	73	78,748	.38	2,184,470
	Tobacco ....pounds..	16,153,000	885	18,252	.07	1,130,711
	Hay ....tons..	1,812,500	1.25	1,450,000	10.48	18,995,000
	Total..............	....	....	9,067,722	....	96,411,175
Illinois	Indian corn........bushels..	278,060,000	35.7	7,788,790	.29	80,637,400
	Wheat..............do....	33,556,000	13.7	2,449,343	.93	31,207,080
	Rye ....do....	4,098,000	15.3	267,862	.54	2,213,076
	Oats..............do....	137,400,000	35.8	3,838,000	.23	31,602,000
	Barley..............do....	904,000	24.3	37,203	.63	569,541
	Buckwheat..............do....	43,000	12.7	3,393	.67	28,644
	Potatoes ....do....	11,706,000	80	146,319	.36	4,213,987
	Tobacco ....pounds..	2,947,000	634	4,648	.08	223,959
	Hay ....tons..	4,625,482	1.40	3,303,916	7.76	35,893,740
	Total..............	....	....	17,839,474	....	186,589,427
Wisconsin	Indian corn........bushels..	32,733,000	30.6	1,069,717	.36	11,783,880
	Wheat..............do....	13,855,000	11.5	1,204,798	.96	13,300,800
	Rye ....do....	3,738,000	13.3	281,027	.65	2,429,478
	Oats..............do....	42,768,000	29.4	1,454,702	.28	11,975,040
	Barley..............do....	10,310,000	22.5	458,205	.60	6,185,768
	Buckwheat..............do....	321,000	10.3	31,167	.60	192,612
	Potatoes ....do....	11,006,000	80	137,580	.32	3,522,048
	Tobacco ....pounds..	12,846,000	930	13,813	.10	1,220,379
	Hay ....tons..	2,165,391	1.25	1,732,313	7.30	15,807,354
	Total..............	....	....	6,383,322	....	66,417,359
Minnesota	Indian corn........bushels..	20,622,000	29.3	703,837	.32	6,599,040
	Wheat..............do....	27,881,000	9.0	3,097,916	.92	25,650,520
	Rye ....do....	426,000	15.3	27,864	.52	221,686
	Oats..............do....	43,540,000	28.7	1,517,076	.26	11,320,400
	Barley..............do....	8,110,000	21.0	386,202	.57	4,622,838
	Buckwheat..............do....	59,000	11.0	5,366	.65	38,367
	Potatoes..............do....	7,587,000	92	82,463	.30	2,275,979
	Hay ....tons..	2,112,500	1.30	1,625,000	4.25	8,978,125
	Total..............	....	....	7,445,724	....	59,706,955

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Iowa	Indian corn........bushels..	278,232,000	35.8	7,771,840	$0.24	$66,775,680
	Wheat ....do....	24,196,000	9.8	2,468,982	.85	20,566,600
	Rye ....do....	1,647,000	15.0	109,823	.50	823,673
	Oats...................do....	67,090,000	26.2	2,560,683	.20	13,418,000
	Barley................do....	4,181,000	21.3	196,304	.55	2,299,701
	Buckwheat...........do....	309,000	11.5	26,842	.66	203,731
	Potatoes..............do....	16,909,000	90	187,880	.29	4,903,668
	Hay ....tons..	5,272,783	1.45	3,636,402	4.62	24,360,257
	Total.................	....	....	16,958,756	....	133,351,310
Missouri	Indian corn........bushels..	202,583,000	31.0	6,534,921	.30	60,774,900
	Wheat................do....	18,496,000	12.0	1,541,343	.88	16,276,480
	Rye ....do....	550,000	11.8	46,600	.53	291,436
	Oats...................do....	34,909,000	25.2	1,385,281	.24	8,378,160
	Barley................do....	164,000	19.4	8,443	.58	95,001
	Buckwheat...........do....	81,000	10.7	7,575	.67	54,306
	Potatoes..............do....	6,044,000	70	86,348	.36	2,175,970
	Tobacco...........pounds..	13,109,000	928	14,126	.08	1,048,714
	Hay ....tons..	1,802,494	1.20	1,502,078	7.36	13,266,356
	Total.................	....	....	11,126,715	....	102,361,323
Kansas	Indian corn........bushels..	158,186,000	26.7	5,924,566	.26	41,128,360
	Wheat................do....	15,960,000	15.2	1,050,000	.88	14,044,800
	Rye ....do....	2,668,000	13.8	193,325	.46	1,227,227
	Oats ....do....	42,654,000	25.3	1,685,926	.22	9,383,880
	Barley................do....	144,000	20.5	7,032	.53	76,403
	Buckwheat...........do....	47,000	12.5	3,749	.65	30,461
	Potatoes..............do....	9,063,000	65	139,436	.48	4,350,403
	Hay ....tons..	1,935,450	1.25	1,548,360	4.20	8,128,890
	Total.................	....	.. ..	10,552,394	....	78,370,424
Nebraska	Indian corn.......bushels..	144,217,000	35.2	4,097,067	.22	31,727,740
	Wheat ....do....	14,508,000	9.3	1,560,021	.83	12,041,640
	Rye ....do....	1,570,000	13.6	115,472	.48	753,801
	Oats...................do....	26,177,000	25.8	1,014,606	.19	4,973,630
	Barley ....do....	3,520,000	22.5	156,428	.52	1,830,208
	Buckwheat...........do....	44,000	11.2	3,914	.62	27,421
	Potatoes ....do....	6,321,000	75	84,283	.36	2,275,641
	Hay ....tons..	1,441,440	1.30	1,108,800	3.75	5,405,400
	Total.................	....	....	8,140,591	....	59,035,481
California	Indian corn.......bushels..	4,314,000	27.8	155,184	.70	3,019,800
	Wheat................do....	28,451,000	12.1	2,351,300	.85	24,183,350
	Rye...................do ...	334,000	11.2	29,801	.67	223,627
	Oats ....do....	1,886,000	25.3	73,760	.60	1,119,600
	Barley................do....	15,735,000	20.0	786,748	.58	9,126,277
	Potatoes..............do....	4,442,000	73	60,843	.61	2,709,339
	Hay ....tons..	1,539,454	1.30	1,184,195	12.03	18,519,632
	Total.................	....	....	4,641,831	....	58,901,625
Oregon	Indian corn ....bushels..	161,000	22.5	7,140	.68	109,480
	Wheat ....do....	14,548,000	16.3	892,425	.78	11,347,440
	Rye ....do....	17,000	12.2	1,393	.64	10,865
	Oats ....do....	5,441,000	26.0	209,278	.40	2,176,400
	Barley ....do....	1,042,000	26.4	39,479	.55	573,235
	Buckwheat ....do....	11,000	13.5	813	.65	7,134
	Potatoes ....do....	2,092,000	105	19,927	.36	753,241
	Hay ....tons..	621,314	1.30	477,934	9.13	5,672,597
	Total	....	....	1,648,389	....	20,650,392
Nevada	Wheat.............bushels..	200,000	16.0	12,500	.92	184,000
	Oats...................do....	206,000	25.5	8,094	.63	129,780
	Barley............ ...do ...	507,000	24.2	20,945	.75	380,152
	Potatoes..............do....	383,000	90	4,260	.67	256,878
	Hay ....tons..	220,078	1.20	183,398	10.83	2,383,445
	Total	....	....	229,197	....	3,334,255
Colorado	Indian corn........bushels..	777,000	22.6	34,394	.57	442,890
	Wheat................do....	2,346,000	17.5	134,074	.90	2,111,400
	Rye ....do ...	29,000	12.2	2,379	.66	19,127
	Oats...................do....	1,664,000	27.4	60,740	.42	698,880
	Barley................do....	319,000	25.8	12,377	.70	223,529
	Potatoes..............do....	2,717,000	94	28,903	.45	1,222,597
	Hay ....tons..	370,013	1.50	246,675	11.40	4,218,148
	Total.........	....	....	519,542	....	8,936,571

Table showing the product of the cereals, potatoes, tobacco, hay, etc.—Continued.

States.	Products.	Quantity produced in 1888.	Average yield per acre.	Number of acres in each crop.	Value per unit of quantity.	Total valuation.
Arizona	Wheat .... bushels..	370,000	15.0	24,695	$0.90	$333,000
	Barley .... do....	459,000	18.3	25,086	.65	298,398
	Potatoes .... do ...	110,000	76	1,441	.68	74,471
	Hay .... tons..	35,343	1.10	32,130	11.00	388,773
	Total	....	....	83,352	....	1,094,642
Dakota	Indian corn .... bushels..	18,816,000	25.5	737,899	.33	6,209,280
	Wheat .... do....	38,036,000	9.7	3,921,269	.91	34,612,760
	Rye .... do....	244,000	13.5	18,090	.46	112,339
	Oats .... do....	34,218,000	27.2	1,258,008	.26	8,896,680
	Barley .... do....	5,207,000	20.3	256,510	.50	2,603,577
	Buckwheat .... do....	51,000	9.9	5,133	.60	30,798
	Potatoes .... do....	4,643,000	80	58,041	.35	1,625,148
	Hay .... tons..	1,215,500	1.30	935,000	3.80	4,618,900
	Total	....	....	7,189,950	....	58,709,482
Idaho	Wheat .... bushels..	1,252,000	16.3	76,818	.87	1,089,240
	Oats .... do....	957,000	27.6	34,684	.35	334,950
	Barley .... do....	391,000	27.0	14,495	.67	262,215
	Potatoes .... do....	535,000	107	5,001	.55	294,309
	Hay .... tons..	162,431	1.15	141,244	7.50	1,218,233
	Total	....	....	272,242	....	3,198,947
Montana	Wheat .... bushels..	2,001,000	16.5	121,255	.85	1,700,850
	Oats .... do....	1,780,000	29.0	61,384	.34	605,200
	Barley .... do....	109,000	28.7	3,804	.65	70,964
	Potatoes .... do....	552,0[illegible]0	120	4,600	.50	276,000
	Hay .... tons..	217,854	1.20	181,545	8.30	1,808,188
	Total	....	....	372,588	....	4,461,202
New Mexico	Indian corn .... bushels..	992,000	18.5	53,609	.67	664,640
	Wheat .... do ...	1,233,000	15.0	82,186	.95	1,171,350
	Oats .... do....	392,000	25.0	15,697	.35	137,200
	Barley .... do....	72,000	21.4	3,369	.62	44,909
	Potatoes .... do....	91,000	75	1,208	.55	49,830
	Hay .... tons..	32,760	1.00	32,760	10.50	343,980
	Total	....	....	188,829	....	2,411,909
Utah	Indian corn .... bushels..	486,000	14.5	33,500	.63	306,180
	Wheat .... do....	1,945,000	16.3	119,299	.76	1,478,200
	Rye .... do....	29,000	12.7	2,287	.69	20,012
	Oats .... do....	986,000	27.7	35,590	.37	364,820
	Barley .... do....	700,000	23.3	30,048	.50	350,059
	Potatoes .... do....	1,005,000	80	12,567	.33	331,769
	Hay .... tons..	210,993	1.30	162,302	7.00	1,476,951
	Total	....	....	395,593	....	4,327,991
Washington	Indian corn .... bushels..	122,000	20.0	6,100	.58	70,760
	Wheat .... do....	9,006,000	18.5	486,791	.78	7,024,680
	Rye .... do....	20,000	13.5	1,483	.73	14,682
	Oats .... do....	3,314,000	35.0	94,687	.35	1,159,900
	Barley .... do....	995,000	30.5	32,643	.55	547,587
	Potatoes .... do....	1,500,000	122	12,291	.34	509,831
	Hay .... tons..	298,697	1.35	221,257	9.00	2,688,273
	Total	....	....	855,252	....	12,015,713
Wyoming	Oats .... bushels..	93,000	27.4	3,388	.36	33,480
	Potatoes .... do....	380,000	95	3,996	.47	178,421
	Hay .... tons..	140,250	1.20	116,875	7.50	1,051,875
	Total	....	....	124,259	....	1,263,776

Summary for each State, showing the product, area, and value of each crop for 1888.

States and Territories.	Corn.			Wheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	596,000	30,878	$447,000	589,000	40,614	$706,800
New Hampshire	846,000	37,421	609,120	152,000	10,380	182,400
Vermont	1,494,000	61,470	986,040	346,000	20,710	408,280
Massachusetts	1,788,000	59,397	1,215,840	....	....	....
Rhode Island	382,000	12,558	267,400	....	....	....
Connecticut	1,778,000	56,977	1,155,700	32,000	2,149	38,400
New York	22,870,000	705,859	13,264,600	9,309,000	660,214	10,239,900
New Jersey	11,351,000	350,335	6,016,030	1,785,000	141,652	1,963,500
Pennsylvania	45,414,000	1,397,350	22,707,000	18,802,000	1,392,728	20,118,140
Delaware	3,844,000	220,927	1,691,360	1,194,000	94,790	1,194,000
Maryland	17,553,000	740,645	7,898,850	7,634,000	557,208	7,634,000
Virginia	34,745,000	2,131,595	17,025,050	5,172,000	623,121	5,172,000
North Carolina	28,343,000	2,673,910	16,438,940	3,835,000	710,268	4,026,750
South Carolina	13,715,000	1,576,388	8,229,000	973,000	194,563	1,089,760
Georgia	28,069,000	2,923,885	16,841,400	1,910,000	374,452	2,101,000
Florida	4,541,000	463,392	2,951,650	....	....	....
Alabama	31,616,000	2,489,475	17,388,800	2,186,000	420,443	2,295,300
Mississippi	28,422,000	1,933,477	15,347,880	532,000	84,375	558,600
Louisiana	15,263,000	1,031,263	8,089,390	....	....	....
Texas	92,436,000	4,814,363	37,898,760	6,066,000	572,226	6,066,000
Arkansas	41,543,000	2,130,399	19,940,640	2,267,000	233,671	2,153,650
Tennessee	75,665,000	3,637,762	31,779,300	10,297,000	1,211,394	9,576,210
West Virginia	16,149,000	678,518	7,751,520	2,899,000	305,199	2,783,040
Kentucky	81,545,000	3,160,668	27,725,300	10,436,000	1,013,228	10,018,560
Ohio	93,018,000	2,862,080	32,556,300	28,705,000	2,657,884	27,843,850
Michigan	29,025,000	967,513	12,190,500	24,028,000	1,645,762	23,547,440
Indiana	125,478,000	3,605,694	38,898,180	28,879,000	2,774,062	27,206,260
Illinois	278,060,000	7,788,790	80,637,400	33,556,000	2,449,343	31,207,080
Wisconsin	32,733,000	1,069,717	11,783,880	13,855,000	1,204,798	13,300,800
Minnesota	20,622,000	703,837	6,599,040	27,881,000	3,097,916	25,650,520
Iowa	278,232,000	7,771,840	66,775,680	24,196,000	2,468,982	20,566,600
Missouri	202,583,000	6,534,921	60,774,900	18,496,000	1,541,343	16,276,480
Kansas	158,186,000	5,924,566	41,128,360	15,960,000	1,050,000	14,044,800
Nebraska	144,217,000	4,097,067	31,727,740	14,508,000	1,560,021	12,041,640
California	4,314,000	155,184	3,019,800	28,451,000	2,351,300	24,183,350
Oregon	161,000	7,140	109,480	14,548,000	892,425	11,347,440
Nevada	....	....	....	200,000	12,500	184,000
Colorado	777,000	34,394	442,890	2,346,000	184,074	2,111,400
Arizona	....	....	....	370,000	24,695	333,000
Dakota	18,816,000	737,899	6,209,280	38,036,000	3,921,269	34,612,760
Idaho	....	....	....	1,252,000	76,818	1,089,240
Montana	....	....	....	2,001,000	121,255	1,700,850
New Mexico	992,000	53,609	664,640	1,233,000	82,186	1,171,350
Utah	486,000	33,500	306,180	1,945,000	119,299	1,478,200
Washington	122,000	6,100	70,760	9,006,000	486,791	7,024,680
Total	1,987,790,000	75,672,763	677,561,580	415,868,000	37,336,138	385,248,030

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	28,000	2,311	$24,959	2,656,000	96,933	$1,142,080
New Hampshire	33,000	2,861	28,701	1,033,000	34,036	454,520
Vermont	75,000	5,797	55,767	3,536,000	108,800	1,449,760
Massachusetts	213,000	18,840	170,314	705,000	25,000	317,250
Rhode Island	15,000	1,278	11,655	174,000	6,353	76,560
Connecticut	348,000	28,500	257,298	1,055,000	39,811	453,650
New York	2,724,000	236,851	1,715,986	40,570,000	1,398,957	15,010,900
New Jersey	1,098,000	105,588	691,812	3,688,000	140,218	1,327,680
Pennsylvania	4,458,000	398,076	2,764,240	35,251,000	1,330,234	11,985,340
Delaware	8,000	857	4,628	450,000	21,839	157,500
Maryland	326,000	30,443	195,444	2,2[illegible]6,000	118,976	757,680
Virginia	375,000	51,322	228,537	8,108,000	659,192	2,918,880
North Carolina	365,000	68,855	299,244	6,078,000	660,657	2,795,880
South Carolina	44,000	8,451	37,353	3,773,000	397,198	2,075,150
Georgia	151,000	28,456	135,735	7,115,000	618,687	3,770,950
Florida	....	....	....	599,000	53,021	365,390
Alabama	31,000	6,171	27,770	4,806,000	417,880	2,306,880
Mississippi	6,000	1,220	5,368	4,096,000	365,722	2,048,000
Louisiana	....	....	....	495,000	41,284	222,750
Texas	57,000	7,623	49,741	13,595,000	609,645	4,350,400
Arkansas	45,000	5,957	35,742	5,135,000	285,273	2,156,700
Tennessee	293,000	39,082	205,181	11,108,000	677,340	3,998,880
West Virginia	148,000	19,023	99,409	2,495,000	145,051	898,200

Summary for each State, showing the product, area, value, etc.—Continued.

States and Territories.	Rye.			Oats.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Kentucky	834,000	89,650	$516,922	8,454,000	491,496	$2,789,820
Ohio	623,000	49,847	361,391	33,819,000	1,063,475	9,469,320
Michigan	279,000	22,304	175,644	26,668,000	803,250	8,000,400
Indiana	468,000	38,037	261,999	28,522,000	1,076,320	7,415,720
Illinois	4,098,000	267,862	2,213,076	137,400,000	3,838,000	31,602,000
Wisconsin	3,738,000	281,027	2,429,478	42,768,000	1,454,702	11,975,040
Minnesota	426,000	27,864	221,686	43,540,000	1,517,076	11,320,400
Iowa	1,647,000	109,823	823,673	67,090,000	2,560,683	13,418,000
Missouri	550,000	46,600	291,436	34,909,000	1,385,281	8,378,160
Kansas	2,668,000	193,325	1,227,227	42,654,000	1,685,926	9,383,880
Nebraska	1,570,000	115,472	753,801	26,177,000	1,014,606	4,973,630
California	334,000	29,801	223,627	1,866,000	73,760	1,119,600
Oregon	17,000	1,393	10,865	5,441,000	209,278	2,176,400
Nevada	....	....	....	206,000	8,094	129,780
Colorado	29,000	2,379	19,127	1,664,000	60,740	698,880
Dakota	244,000	18,090	112,339	34,218,000	1,258,008	8,896,680
Idaho	....	....	....	957,000	34,684	334,950
Montana	....	....	....	1,780,000	61,384	605,200
New Mexico	....	....	....	392,000	15,697	137,200
Utah	29,000	2,287	20,012	986,000	35,590	364,820
Washington	20,000	1,483	14,682	3,314,000	94,687	1,159,900
Wyoming	....	....	....	93,000	3,388	33,480
Total	28,415,000	2,364,805	16,721,869	701,735,000	26,998,282	195,424,240

States and Territories.	Barley.			Buckwheat.		
	Bushels.	Acres.	Value.	Bushels.	Acres.	Value.
Maine	240,000	11,318	$165,560	220,000	21,343	$127,503
New Hampshire	81,000	3,780	54,750	56,000	4,880	31,988
Vermont	257,000	11,594	169,875	240,000	18,041	134,369
Massachusetts	69,000	3,280	50,971	65,000	5,441	45,704
Rhode Island	20,000	848	14,946	....	....	....
Connecticut	14,000	638	9,876	134,000	10,974	87,024
New York	7,418,000	343,428	5,192,632	4,514,000	311,310	2,798,677
New Jersey	....	....	....	464,000	35,723	329,723
Pennsylvania	458,000	26,951	297,809	3,881,000	277,189	2,522,420
Maryland	....	....	....	143,000	11,439	95,802
Virginia	18,000	1,209	11,606	242,000	24,187	145,122
North Carolina	....	....	....	69,000	6,592	40,145
Texas	188,000	15,643	84,472	....	....	....
Tennessee	36,000	3,237	21,752	44,000	5,515	26,472
West Virginia	13,000	578	7,884	373,000	40,121	242,531
Kentucky	245,000	10,800	161,806	....	....	....
Ohio	584,000	26,067	373,697	144,000	11,633	100,974
Michigan	967,000	42,977	638,209	405,000	32,394	222,709
Indiana	406,000	18,713	255,825	90,000	7,896	63,010
Illinois	904,000	37,203	569,541	43,000	3,393	28,644
Wisconsin	10,310,000	458,205	6,185,768	321,000	31,167	192,612
Minnesota	8,110,000	386,202	4,622,838	59,000	5,366	38,367
Iowa	4,181,000	190,304	2,299,701	309,000	26,842	203,731
Missouri	164,000	8,443	95,001	81,000	7,575	54,306
Kansas	144,000	7,032	76,403	47,000	3,740	30,461
Nebraska	3,520,000	156,428	1,830,208	44,000	3,914	27,421
California	15,735,000	786,748	9,126,277	....	....	....
Oregon	1,042,000	39,479	573,235	11,000	813	7,134
Nevada	507,000	20,945	380,152	....	....	....
Colorado	319,000	12,377	223,529	....	....	....
Arizona	459,000	25,086	298,398	....	....	....
Dakota	5,207,000	256,510	2,603,577	51,000	5,133	30,798
Idaho	391,000	14,495	262,215	....	....	....
Montana	109,000	3,804	70,964	....	....	....
New Mexico	72,000	3,369	44,909	....	....	....
Utah	700,000	30,048	350,059	....	....	....
Washington	996,000	32,643	547,587	....	....	....
Total	63,884,000	2,996,382	37,672,032	12,050,000	912,630	7,627,647

Summary for each State, showing the product, area, value, etc.—Continued.

States and Territories.	Potatoes.			Hay.		
	Bushels.	Acres.	Value.	Tons.	Acres.	Value.
Maine	7,882,000	71,651	$3,625,541	1,292,791	1,319,174	$13,897,503
New Hampshire	3,072,000	30,114	1,443,665	644,729	678,662	6,769,655
Vermont	3,876,000	38,761	1,627,962	1,038,303	1,038,303	9,760,048
Massachusetts	3,632,000	35,964	1,997,600	674,365	642,252	10,621,249
Rhode Island	668,000	6,889	367,528	104,829	104,829	1,656,298
Connecticut	2,677,000	33,459	1,418,662	574,419	563,156	8,443,959
New York	29,688,000	371,105	11,281,592	5,426,757	4,933,415	61,051,016
New Jersey	3,599,000	43,366	1,799,689	586,386	488,655	7,476,422
Pennsylvania	16,305,000	203,810	6,521,920	2,997,068	2,724,607	32,967,748
Delaware	317,000	4,224	152,064	66,363	56,240	862,719
Maryland	1,654,000	21,204	760,800	376,239	327,164	4,800,810
Virginia	2,346,000	36,098	1,173,185	387,936	369,463	5,043,168
North Carolina	1,377,000	21,856	895,003	154,332	140,302	2,021,749
South Carolina	274,000	4,563	246,402	33,810	29,400	447,983
Georgia	638,000	10,291	574,238	47,995	39,996	646,013
Florida	155,000	2,806	142,142	....	....	....
Alabama	601,000	10,018	456,821	51,383	41,106	637,149
Mississippi	674,000	10,370	505,538	58,968	45,360	714,692
Louisiana	511,000	7,623	408,593	78,331	58,023	825,609
Texas	700,000	11,296	525,264	189,795	151,836	1,465,217
Arkansas	864,000	12,891	423,212	56,235	44,988	584,844
Tennessee	2,407,000	40,113	1,131,187	321,071	267,559	3,531,781
West Virginia	1,849,000	28,443	850,446	397,345	397,345	4,561,521
Kentucky	3,228,000	52,072	1,646,517	345,534	329,080	4,146,408
Ohio	11,925,000	149,059	4,412,146	2,960,066	2,573,970	33,034,337
Michigan	8,611,000	119,599	2,841,672	1,545,317	1,404,834	17,307,550
Indiana	5,749,000	78,748	2,184,470	1,812,500	1,450,000	18,995,000
Illinois	11,706,000	146,319	4,213,987	4,625,482	3,303,916	35,893,740
Wisconsin	11,006,000	137,580	3,522,048	2,165,391	1,732,313	15,807,354
Minnesota	7,587,000	82,463	2,275,979	2,112,500	1,625,000	8,978,125
Iowa	16,909,000	187,880	4,903,668	5,272,783	3,636,402	24,360,257
Missouri	6,044,000	86,348	2,175,970	1,802,494	1,502,078	13,266,356
Kansas	9,063,000	139,436	4,350,403	1,935,450	1,548,360	8,128,890
Nebraska	6,321,000	84,283	2,275,641	1,441,440	1,108,800	5,405,400
California	4,442,000	60,843	2,709,339	1,539,454	1,184,195	18,519,632
Oregon	2,092,000	19,927	753,241	621,314	477,934	5,672,597
Nevada	383,000	4,260	256,878	220,078	183,398	2,383,445
Colorado	2,717,000	28,903	1,222,597	370,013	246,675	4,218,148
Arizona	110,000	1,441	74,471	35,343	32,130	388,773
Dakota	4,643,000	58,041	1,625,148	1,215,500	935,000	4,618,900
Idaho	535,000	5,001	294,309	162,431	141,244	1,218,233
Montana	552,000	4,600	276,000	217,854	181,545	1,808,188
New Mexico	91,000	1,208	49,830	32,760	32,760	343,980
Utah	1,005,000	12,567	331,769	210,993	162,302	1,476,951
Washington	1,500,000	12,291	509,831	298,697	221,257	2,688,273
Wyoming	380,000	3,996	178,421	140,250	116,875	1,051,875
Total	202,365,000	2,533,280	81,413,589	46,643,094	38,591,903	408,499,565

States and Territories.	Tobacco.			Cotton.		
	Pounds.	Acres.	Value.	Bales.	Acres.	Value.
Massachusetts	3,893,000	2,464	$486,640	....	....	....
Connecticut	9,603,000	6,136	1,248,369	....	....	....
New York	6,488,000	6,179	778,554	....	....	....
Pennsylvania	24,180,000	19,500	2,587,260	....	....	....
Maryland	14,017,000	33,775	770,914	....	....	....
Virginia	64,034,000	127,052	3,842,052	13,852	42,351	$551,876
North Carolina	25,755,000	57,107	1,931,644	364,576	1,071,633	15,029,653
South Carolina	....	....	....	552,248	1,646,518	22,672,553
Georgia	....	....	....	953,623	2,970,901	39,394,147
Florida	....	....	....	68,543	259,990	2,533,343
Alabama	....	....	....	905,315	2,851,743	38,783,705
Mississippi	....	....	....	1,057,746	2,592,001	45,028,241
Louisiana	....	....	....	446,778	1,088,191	18,904,054
Texas	....	....	....	1,594,305	4,158,343	67,764,358
Arkansas	1,156,000	2,408	80,909	597,290	1,416,431	25,283,293
Tennessee	45,641,000	67,119	3,651,274	357,596	881,473	14,985,041
West Virginia	4,496,000	5,620	359,680	....	....	....
Kentucky	283,306,000	323,409	21,247,971	....	....	....
Ohio	35,195,000	39,105	2,745,171	....	....	....
Indiana	16,153,000	18,252	1,130,711	....	....	....
Illinois	2,947,000	4,648	223,959	....	....	....
Wisconsin	12,843,000	13,813	1,220,379	....	....	....
Missouri	13,109,000	14,126	1,048,714			
All other States and Territories, including Missouri for cotton	2,976,000	6,613	312,464	29,026	79,016	1,208,945
Total	565,795,000	747,326	43,666,665	6,940,898	19,058,591	292,139,209

Table showing the average yield per acre and price per bushel, pound, or ton of farm products for the year 1888.

States and Territories.	Corn.		Wheat.		Rye.		Oats.		Barley.	
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Bushels.	Price per bushel.
Maine	19.3	$0.75	14.5	$1.20	12.1	$0.89	27.4	$0.43	21.2	$0.69
New Hampshire	22.6	.72	14.6	1.20	11.5	.87	30.3	.44	21.4	.68
Vermont	21.3	.66	16.7	1.18	12.9	.74	32.5	.41	22.2	.66
Massachusetts	30.1	.68	....	....	11.3	.80	28.2	.45	21.0	.74
Rhode Island	30.4	.70	....	....	11.7	.78	27.4	.44	23.6	.75
Connecticut	31.2	.65	14.9	1.20	12.2	.74	26.5	.43	21.9	.71
New York	32.4	.58	14.1	1.10	11.5	.68	29.0	.37	21.6	.70
New Jersey	32.4	.53	12.6	1.10	10.4	.63	26.3	.36	....	....
Pennsylvania	32.5	.50	13.5	1.07	11.2	.62	26.5	.34	17.0	.65
Delaware	17.4	.44	12.6	1.00	9.3	.59	20.6	.35	....	....
Maryland	23.7	.45	13.7	1.00	10.7	.60	19.3	.33	....	....
Virginia	16.3	.49	8.3	1.00	7.3	.61	12.3	.36	14.9	.64
North Carolina	10.6	.58	5.4	1.05	5.3	.82	9.9	.46	....	....
South Carolina	8.7	.60	5.0	1.12	5.2	.85	9.5	.55	....	....
Georgia	9.6	.60	5.1	1.10	5.3	.90	11.5	.53	....	....
Florida	9.8	.65	....	....	....	....	11.3	.61	....	....
Alabama	12.7	.55	5.2	1.05	5.0	.90	11.5	.43	....	....
Mississippi	14.7	.54	6.3	1.05	4.9	.89	11.2	.50	....	....
Louisiana	14.8	.53	....	....	....	....	12.0	.45	....	....
Texas	19.2	.41	10.6	1.00	7.5	.87	22.3	.32	12.0	.45
Arkansas	19.5	.48	9.7	.95	7.6	.79	18.0	.42	....	....
Tennessee	20.8	.42	8.5	.93	7.5	.70	16.4	.36	11.1	.60
West Virginia	23.8	.48	9.5	.96	7.8	.67	17.2	.36	22.5	.61
Kentucky	25.3	.34	10.3	.96	9.3	.62	17.2	.33	22.7	.63
Ohio	32.5	.35	10.8	.97	12.5	.53	31.6	.28	22.4	.64
Michigan	30.0	.42	14.6	.98	12.5	.63	35.2	.30	22.5	.66
Indiana	34.8	.31	10.4	.94	12.2	.56	26.5	.26	21.7	.63
Illinois	35.7	.29	13.7	.93	13.3	.51	35.8	.23	24.3	.62
Wisconsin	30.6	.36	11.5	.96	13.3	.65	29.4	.28	22.5	.60
Minnesota	29.3	.32	9.0	.92	15.3	.52	28.7	.26	21.0	.57
Iowa	35.8	.24	9.8	.85	15.0	.50	26.2	.20	21.3	.55
Missouri	31.0	.30	12.0	.88	11.8	.53	25.2	.24	19.4	.53
Kansas	36.7	.26	15.2	.88	13.8	.46	25.3	.22	20.5	.53
Nebraska	35.2	.22	9.3	.82	13.6	.45	25.8	.19	24.5	.52
California	27.8	.70	12.1	.86	11.2	.67	25.3	.60	30.0	.58
Oregon	22.5	.63	16.3	.78	12.2	.64	26.0	.40	26.4	.55
Nevada	....	....	16.0	.92	....	....	25.5	.63	24.2	.75
Colorado	22.6	.57	17.5	.90	12.2	.66	27.4	.42	25.8	.70
Arizona	....	....	15.0	.90	....	....	....	....	18.3	.65
Dakota	25.5	.33	9.7	.91	13.5	.46	27.2	.26	20.3	.50
Idaho	....	....	16.3	.87	....	....	27.6	.35	27.0	.67
Montana	....	....	16.5	.85	....	....	29.0	.34	28.7	.65
New Mexico	18.5	.67	15.0	.95	....	....	25.0	.35	21.4	.62
Utah	14.5	.63	16.3	.76	12.7	.69	27.7	.37	23.3	.50
Washington	20.0	.58	18.5	.78	13.5	.73	35.0	.35	30.5	.55
Wyoming	....	....	....	....	....	....	27.4	.36	....	....
Average	26.3	.341	11.1	.926	12.0	.588	26.0	.278	21.3	.590

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.		
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Pounds.	Price per pound.
Maine	10.3	$0.58	110	$0.46	.98	$10.75	....	....	....	....	....
New Hampshire	11.5	.57	102	.47	.95	10.50	....	....	....	....	....
Vermont	13.3	.56	100	.42	1.00	9.40	....	....	....	....	....
Massachusetts	11.9	.70	101	.55	1.05	15.75	1,580	$0.13	....	....	....
Rhode Island	....	....	97	.55	1.00	15.80	....	....	....	....	....
Connecticut	12.2	.65	80	.53	1.02	14.70	1,565	.13	....	....	....
New York	14.5	.62	80	.38	1.10	11.25	1,050	.12	....	....	....
New Jersey	13.0	.71	83	.50	1.20	12.75	....	....	....	....	....
Pennsylvania	14.0	.65	80	.40	1.10	11.00	1,240	.11	....	....	....
Delaware	....	....	75	.48	1.18	13.00	....	....	....	....	....
Maryland	12.5	.67	78	.46	1.15	12.76	415	.05	....	....	....
Virginia	10.0	.60	65	.50	1.05	13.00	504	.06	.327	157	$0.083
North Carolina	10.5	.58	63	.65	1.10	13.10	451	.08	.340	165	.085
South Carolina	....	....	60	.90	1.15	13.25	....	....	.335	162	.085
Georgia	....	....	62	.90	1.20	13.46	....	....	.321	156	.085
Florida	....	....	67	.92	....	....	....	....	.264	116	.084
Alabama	....	....	60	.76	1.25	12.40	....	....	.317	160	.085
Mississippi	....	....	65	.75	1.30	12.12	....	....	.408	202	.086
Louisiana	....	....	67	.80	1.35	10.54	....	....	.411	202	.086
Texas	....	....	62	.75	1.25	7.72	....	....	.383	194	.084
Arkansas	....	....	67	.49	1.25	10.40	480	.07	.422	210	.085
Tennessee	8.0	.60	60	.47	1.20	11.00	680	.08	.406	200	.085

Table showing the average yield per acre and price per bushel, etc.—Continued.

States and Territories.	Buckwheat.		Potatoes.		Hay.		Tobacco.		Cotton.		
	Bushels.	Price per bushel.	Bushels.	Price per bushel.	Tons.	Price per ton.	Pounds.	Price per pound.	Bales.	Pounds.	Price per pound.
West Virginia	9.3	$0.65	65	$0.46	1.00	$11.48	800	$0.08			
Kentucky	....	....	62	.51	1.05	12.00	876	.08			
Ohio	12.4	.70	80	.37	1.15	11.16	900	.03			
Michigan	12.5	.55	72	.33	1.10	11.20	....	....			
Indiana	11.4	.70	73	.38	1.25	10.48	885	.07			
Illinois	12.7	.67	80	.36	1.40	7.76	634	.08			
Wisconsin	10.3	.60	80	.32	1.25	7.30	930	.10			
Minnesota	11.0	.65	93	.30	1.30	4.25	....	....			
Iowa	11.5	.66	90	.29	1.45	4.62	....	....			
Missouri	10.7	.67	70	.36	1.20	7.36	928	.03			
Kansas	12.5	.65	65	.48	1.25	4.20					
Nebraska	11.2	.62	75	.36	1.30	3.75			.367	180	$0.085
California	....	....	73	.61	1.30	12.03					
Oregon	13.5	.65	105	.36	1.30	9.13					
Nevada	....	....	90	.67	1.20	10.83					
Colorado	....	....	94	.45	1.50	11.40					
Arizona	....	....	76	.68	1.10	11.00	450	.10			
Dakota	9.9	.60	80	.35	1.30	3.80					
Idaho	....	....	107	.55	1.15	7.50					
Montana	....	....	120	.50	1.20	8.30					
New Mexico	....	....	75	.55	1.00	10.50					
Utah	....	....	80	.33	1.30	7.00					
Washington	....	....	122	.34	1.35	9.00					
Wyoming	....	....	95	.47	1.20	7.50					
Average	13.2	.633	79.9	.402	1.21	8.76	757.1	.077	.364	180.4	.085

Table showing the average cash value per acre of farm products for the year 1888.

States and Territories.	Corn.	Wheat.	Rye.	Oats.	Barley.	Buckwheat.	Potatoes.	Hay.	Tobacco.	Cotton.
Maine	$14.48	$17.39	$10.80	$11.78	$14.63	$5.97	$50.60	$10.54	....	....
New Hampshire	16.28	17.57	10.03	13.33	14.48	6.55	47.94	9.55	....	....
Vermont	16.04	19.71	9.62	13.33	14.65	7.45	42.00	9.46	....	....
Massachusetts	20.47	....	9.04	12.69	15.54	8.40	55.55	16.54	$197.50	....
Rhode Island	21.29	....	9.12	12.05	17.63	....	53.35	15.80	....	....
Connecticut	20.28	17.87	9.63	11.40	15.48	7.93	42.40	14.99	203.45	....
New York	18.79	15.51	7.25	10.73	15.12	8.99	30.40	12.38	126.00	....
New Jersey	17.17	13.86	6.55	9.47	....	9.23	41.50	15.30	....	....
Pennsylvania	16.25	14.45	6.94	9.01	11.05	9.10	32.00	12.10	132.68	....
Delaware	7.66	12.60	5.40	7.21	....	....	36.00	15.34	....	....
Maryland	10.66	13.70	6.42	6.37	....	8.38	35.88	14.67	22.82	....
Virginia	7.99	8.30	4.45	4.43	9.60	6.00	32.50	13.65	30.24	$13.03
North Carolina	6.15	5.67	4.35	4.23	....	6.09	40.95	14.41	33.82	14.03
South Carolina	5.22	5.60	4.42	5.22	....	....	54.00	15.24	....	13.77
Georgia	5.76	5.61	4.77	6.10	....	....	55.80	16.15	....	13.26
Florida	6.37	....	....	6.89	....	....	61.64	....	....	9.74
Alabama	6.98	5.46	4.50	5.52	....	....	45.60	15.50	....	13.60
Mississippi	7.94	6.62	4.40	5.60	....	....	48.75	15.76	....	17.37
Louisiana	7.84	....	....	5.40	....	....	53.60	14.23	....	17.37
Texas	7.87	10.60	6.53	7.14	5.40	....	46.50	9.65	....	16.30
Arkansas	9.36	9.22	6.00	7.56	....	....	32.83	13.00	33.60	17.85
Tennessee	8.74	7.91	5.25	5.90	6.72	4.80	28.20	13.20	54.40	17.00
West Virginia	11.42	9.12	5.23	6.19	13.64	6.04	29.90	11.48	64.00	
Kentucky	8.77	9.89	5.77	5.68	14.98	....	31.62	12.60	65.70	
Ohio	11.38	10.48	7.25	8.90	14.34	8.68	29.60	12.83	70.20	
Michigan	12.60	14.31	7.88	9.96	14.85	6.88	22.76	12.52	....	
Indiana	10.79	9.81	6.89	6.89	13.67	7.98	27.74	13.10	61.95	
Illinois	10.35	12.74	8.26	8.23	15.31	8.44	28.80	10.86	48.18	
Wisconsin	11.02	11.04	8.64	8.23	13.50	6.18	25.60	9.12	88.35	
Minnesota	9.38	8.23	7.96	7.46	11.97	7.15	27.60	5.53	....	
Iowa	8.59	8.33	7.50	5.24	11.71	7.59	26.10	6.70	....	
Missouri	9.30	10.56	6.25	6.05	11.25	7.17	25.20	8.83	74.24	
Kansas	6.94	13.38	6.35	5.57	10.87	8.13	31.20	5.25		
Nebraska	7.74	7.72	6.53	4.90	11.70	7.01	27.00	4.88		15.30
California	19.46	10.29	7.50	15.18	11.60	....	44.53	15.64		
Oregon	15.33	12.72	7.80	10.40	14.52	3.77	37.80	11.87		
Nevada	....	14.72	....	16.03	18.15	....	60.30	13.00		
Colorado	12.88	15.75	8.04	11.51	18.06	....	42.30	17.10		
Arizona	....	13.48	....	....	11.90	....	51.68	12.10		
Dakota	8.41	8.83	6.21	7.07	10.15	6.00	28.00	4.94	47.25	
Idaho	....	14.18	....	9.66	18.09	....	58.85	8.63		
Montana	....	14.03	....	9.86	18.66	....	60.00	9.96		
New Mexico	12.40	14.25	....	8.74	13.33	....	41.25	10.50		
Utah	9.14	12.39	8.75	10.25	11.65	....	26.40	9.10		
Washington	11.60	14.43	9.90	12.25	16.78	....	41.48	12.15		
Wyoming	....	....	....	9.88	....	....	44.65	9.00		
General average	8.95	10.32	7.07	7.24	12.57	8.36	32.14	10.59	58.43	15.33

General summary showing the estimated quantities, number of acres, and the aggregate value of the crops of the farm in 1888.

Products.	Quantity produced.	Number of acres.	Value.
Indian corn ....bushels..	1,987,790,000	75,672,763	$677,561,580
Wheat ....do....	415,868,000	37,336,138	385,248,030
Rye ....do....	28,415,000	2,364,805	16,721,869
Oats ....do....	701,735,000	26,998,282	195,424,240
Barley ....do....	63,884,000	2,996,382	37,672,032
Buckwheat ....do....	12,050,000	912,630	7,627,647
Potatoes ....do....	202,365,000	2,533,280	81,413,589
Total........	....	148,814,280	1,401,668,987
Tobacco ....pounds..	565,795,000	747,326	43,666,665
Hay ....tons..	46,643,094	38,591,903	408,499,565
Cotton ....bales..	6,940,898	19,058,591	292,139,209
Grand total........	....	207,212,100	2,145,974,426

Table showing the average yield and cash value per acre and price per unit of quantity of farm products for the year 1888.

Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.	Products.	Average yield per acre.	Average price per unit of quantity.	Average value per acre.
Indian corn...bushels..	26.3	$0.341	$8.95	Buckwheat..bushels..	13.2	$0.633	$8.36
Wheat..........do....	11.1	.926	10.32	Potatoes....... do....	79.9	.402	32.14
Rye..........do....	12.0	.588	7.07	Tobacco .....pounds..	757.1	.077	58.43
Oats..........do....	26.0	.278	7.24	Hay..........tons..	1.21	8.76	10.59
Barley..........do....	21.3	.590	12.57	Cotton ....pounds..	180.4	.085	15.33

FARM ANIMALS.

There has been for several years an interest in horse-breeding that has been wide-spread, and it has by no means subsided. It is gradually modifying and molding the stocks of all portions of the country. The tendency is towards larger horses for farm work, for roadsters, stage horses, and for freighting. The favorite breeds of England and the north of France are still imported and regarded with great favor in the West.

The number of mules is estimated at 2,331,027. The number reported a year ago was 2,257,574. The largest increase is west of the Mississippi. There are few north of latitude 40°, though some farmers in the northern belt regard them as cheaper than horses for farm work. In some of the Southern States Texas mules have largely taken the place of oxen. For plantation work they have always been in strong competition with horses. In many districts they have been partially displaced by Texan ponies. Missouri is still the great mule-raising district.

The number of milch cows is necessarily increasing, somewhat unequally, as attention is locally directed to dairying. The dairy is a prominent resource of Eastern farmers, not only for milk but for butter, notwithstanding Western competition. Creameries are still increasing in the New England States, as farmers keep the skim-milk for feeding, and thus retain the fertility of their lands. Virginia and North Carolina are engaged in dairying operations considerably, making a demand for cows. Wisconsin and Minnesota

are rapidly increasing the numbers of milch cows, and introducing or breeding Jerseys and other milk breeds. The estimated number of milch cows on farms is estimated at 15,952,883.

The apparent numbers, as estimated, indicate an increase in ten years of 40 per cent. in cattle other than milch cows, and 33 per cent. in all cattle. They come to maturity somewhat earlier, and it is found that beef can not be made at a profit without steady flesh-making, summer and winter. This causes some increase in the amount of beef produced.

The winter losses on the range constitute another element of uncertainty. They are light in some winters and in others very heavy, and only partially known to the ranchmen themselves, except as approximately determined at the summer round-up. The difference between a loss of 5 per cent. and 25 is a demoralizing element in stock estimates as well as in stock profits.

The numbers of sheep declined annually, under the operation of the tariff reduction of 1883, from 50,626,626 as estimated in 1884 to 42,599,079 in 1889. The lowest prices were reached in 1886. In 1887 there was a slight increase in price, and the decline in numbers would have been arrested but for the continued threat of free admission of the wools of the world. The desirability of American wools and their diminished product naturally tended to increase the price, which stiffened slightly the market value of sheep, in the face of the uncertainty as to its future, which induced timid growers to reduce further their flocks or go out of the business altogether. It is worthy of notice that our local estimates for the present year quite uniformly show an enlargement of numbers, and also an increase in price, while values of all other farm animals are declining. There is perhaps no industry that is so sensitive as wool-growing, responding so quickly to appreciation or depreciation of price. The reason evidently is that it is almost the only animal industry that is liable to foreign competition, and is thus exposed to the hostilities and uncertainties of national legislation.

The increase in the number of swine is in proportion to advance in population. This is especially noticeable in the South, which had a large breadth of corn last year and an increase in nitrogenous forage. There is also some increase in the West.

The numbers of each species of domestic animals on farms and ranches, not including those held in towns and cities, are thus estimated:

Stock.	1889.	1890.	Increase or decrease.
Horses	13,663,294	14,213,837	+ 550,543
Mules	2,257,574	2,331,027	+ 73,453
Milch cows	15,298,625	15,952,883	+ 654,258
Oxen and other cattle	35,032,417	36,849,024	+1,816,607
Sheep	42,599,079	44,336,072	+1,736,993
Swine	50,301,592	51,602,780	+1,301,188

VALUES.

The present returns of our correspondents show a general continuation of the tendency toward lower values which has been noted for several years, sheep alone marking an exception. The decline in price has been sufficient to reduce seriously the aggregate value of all classes of stock from that reported last year.

The heaviest decline of the year has been in the case of horses, amounting to $3.05 per head, and the reported increase in numbers has not been sufficient to offset this loss. With the aggregate number of horses increased by more than 500,000 head, their total value is less than that of last year by more than $3,500,000. The decline in the price of mules is less than one-half as much per head as that of horses, $1.24, and the increase in numbers more than makes good this loss.

Milch cows show a decline of $1.80, and oxen and other cattle $1.84 per head, from the prices of January 1, 1889. In the two classes together there has been an increase in numbers amounting to 2,470,865, but their aggregate value is less than that of a year ago by $49,685,918. The magnitude of this shrinkage in our cattle value will be best appreciated by a comparison of the present returns with those of 1884, when the average price of both classes reached the highest figure shown during the past decade. In that year the aggregate value was $1,106,715,703, while the present return makes it but $913,777,270, a decrease of $192,938,433 during six years, despite the fact that within that period there has been an increase in numbers amounting to more than 10,000,000 head.

The present returns show a revival of interest in sheep husbandry, the decline in numbers which has steadily continued since 1884 having been checked and a gratifying increase in numbers over last year reported. This revival of interest was first manifest in prices in 1887, and has since been slowly checking the decline in numbers. The present returns show an increased valuation per head over that of last year, amounting to 14 cents, the aggregate value showing an increase of slightly over $10,000,000.

Swine show an increase in numbers during the year of more than one and a quarter million, but the price has declined during the same period from $5.79 to $4.72, and the total value has fallen off $47,888,857.

The following statement, giving the total value of the different classes of stock in 1889 and 1890, strikingly shows the heavy shrinkage in stock values which has taken place during the past year:

Stock.	1889.	1890.	Increase or decrease.
Horses	$982,194,827	$978,516,562	— $3,678,265
Mules	179,444,481	182,394,099	+ 2,949,618
Milch cows	366,226,376	353,152,133	— 13,074,243
Oxen and other cattle	597,236,812	560,625,137	— 36,611,675
Sheep	90,640,369	100,659,761	+ 10,019,392
Swine	291,307,193	243,418,336	— 47,888,857
Total	2,507,050,058	2,418,766,028	— 88,284,030

Interesting in connection with this showing of the aggregate values is a statement of the average price per head of each class of animals at the same date:

Stock.	1889.	1890.	Increase or decrease.
Horses	71.89	68.84	— 3.05
Mules	79.49	78.25	— 1.24
Milch cows	23.94	22.14	— 1.80
Oxen and other cattle	17.05	15.21	— 1.84
Sheep	2.13	2.27	+ 0.14
Swine	5.79	4.72	— 1.07

Estimated number of animals on farms and ranches, total value of each kind, and average price January, 1890.

States and Territories.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	99,657	$94.20	$9,338,168	....	....	....
New Hampshire	52,402	88.97	4,662,079	....	....	....
Vermont	84,353	79.64	6,718,276	....	....	....
Massachusetts	63,838	104.61	6,678,327	....	....	....
Rhode Island	10,258	108.24	1,110,325	....	....	....
Connecticut	51,376	104.01	5,343,490	....	....	....
New York	673,950	96.20	64,834,410	5,288	$101.66	$537,577
New Jersey	96,294	103.14	9,931,703	9,501	114.85	1,091,214
Pennsylvania	606,931	93.87	56,973,887	24,021	104.18	2,502,471
Delaware	23,000	91.46	2,103,580	4,184	110.48	462,269
Maryland	130,303	74.09	9,654,144	13,761	103.18	1,419,846
Virginia	259,317	70.08	18,172,031	36,083	86.37	3,116,584
North Carolina	154,229	73.58	11,347,464	96,295	81.84	7,881,118
South Carolina	70,303	87.91	6,180,143	79,269	96.69	7,664,256
Georgia	115,629	82.87	9,582,125	155,700	97.11	15,119,264
Florida	34,737	78.94	2,741,986	13,000	96.59	1,255,694
Alabama	134,805	72.26	9,740,488	143,258	86.95	12,456,913
Mississippi	139,468	65.95	9,198,458	196,436	86.59	17,008,569
Louisiana	124,650	51.84	6,461,356	94,785	85.23	8,078,679
Texas	1,350,344	32.97	44,527,176	213,146	53.22	11,343,579
Arkansas	187,153	56.71	10,612,675	129,866	69.63	9,042,968
Tennessee	303,206	70.75	21,452,283	229,246	71.22	16,327,002
West Virginia	146,647	65.73	9,638,581	6,867	74.91	514,411
Kentucky	390,577	72.90	28,474,801	155,858	75.15	11,712,918
Ohio	771,667	81.09	62,570,402	24,472	87.99	2,153,409
Michigan	477,407	84.22	40,206,792	6,095	98.02	597,427
Indiana	667,577	78.91	52,677,062	53,827	80.07	4,310,109
Illinois	1,123,973	74.11	83,301,912	109,947	78.84	8,668,039
Wisconsin	437,820	76.91	33,673,249	7,066	86.43	610,681
Minnesota	394,783	77.92	30,761,148	11,412	88.51	1,010,023
Iowa	1,095,300	72.70	79,626,009	42,316	78.96	3,341,065
Missouri	789,769	59.75	47,189,413	230,097	67.79	15,597,676
Kansas	726,318	63.49	46,117,430	94,714	75.98	7,195,907
Nebraska	542,036	69.71	37,787,194	45,792	88.24	4,040,759
California	372,084	63.60	23,664,984	42,803	78.21	3,347,496
Oregon	186,841	45.39	8,480,719	3,315	59.72	197,958
Nevada	51,523	55.30	2,849,279	2,369	67.36	159,585
Colorado	137,835	55.37	7,631,317	8,000	87.06	696,487
Arizona	32,670	46.50	1,519,155	2,936	70.00	205,520
Dakota	296,555	69.69	20,667,317	16,682	89.70	1,496,401
Idaho	137,865	42.00	5,790,330	1,704	58.00	98,832
Montana	216,495	41.53	8,989,946	2,450	55.23	135,316
New Mexico	52,350	29.66	1,552,854	10,263	48.65	499,282
Utah	139,399	34.71	4,838,522	4,055	44.10	178,842
Washington	118,633	63.54	7,537,475	1,268	85.22	108,069
Wyoming	141,570	39.25	5,556,097	2,880	72.88	209,884
Total	14,213,837	68.84	978,516,562	2,331,027	78.25	182,394,099

Estimated number of animals on farms and ranches, total value of each kind, and average price January, 1890.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	175,949	$25.00	$4,398,725	157,386	$23.76	$3,739,024
New Hampshire	103,011	27.63	2,846,194	116,169	23.87	2,772,447
Vermont	234,642	23.75	5,572,748	169,053	22.68	3,834,563
Massachusetts	174,729	32.50	5,678,693	98,774	25.24	2,492,663
Rhode Island	24,041	31.00	745,271	12,194	27.25	332,257
Connecticut	134,897	31.08	4,192,599	102,143	27.20	2,778,071
New York	1,552,373	28.11	43,637,205	783,634	28.12	22,034,214
New Jersey	183,493	34.47	6,325,004	67,856	28.92	1,962,417
Pennsylvania	938,665	28.06	26,338,940	852,267	23.67	20,175,387
Delaware	29,543	27.50	812,433	26,866	24.78	665,614
Maryland	141,826	24.36	3,454,881	127,335	18.53	2,358,908
Virginia	272,036	19.28	5,244,854	419,523	15.66	6,569,393
North Carolina	272,155	16.04	4,365,366	398,414	10.47	4,170,321
South Carolina	156,575	21.40	3,350,705	210,396	13.15	2,767,004
Georgia	354,618	17.24	6,113,614	580,816	11.03	6,408,205
Florida	54,951	16.40	901,196	565,201	8.88	5,016,334
Alabama	311,805	15.80	4,926,519	454,642	8.94	4,060,682
Mississippi	309,234	15.38	4,756,019	441,862	9.34	4,126,898

Estimated number of animals on farms and ranches, etc.—Continued.

States and Territories.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Louisiana	177,613	$16.32	$2,898,644	295,731	$9.76	$2,884,941
Texas	843,342	14.15	11,933,289	7,167,853	8.83	63,294,293
Arkansas	329,121	13.62	4,482,628	587,212	8.64	5,072,101
Tennessee	377,740	16.98	6,414,025	484,578	11.68	5,660,645
West Virginia	179,939	21.52	3,872,287	286,528	18.00	5,156,882
Kentucky	317,093	21.69	6,877,747	523,728	17.69	9,263,546
Ohio	791,316	24.80	19,624,637	986,601	22.62	22,317,518
Michigan	454,926	26.24	11,937,258	547,716	21.38	11,710,832
Indiana	602,354	21.48	12,938,564	957,843	18.82	18,027,577
Illinois	1,072,473	22.62	24,259,339	1,713,966	18.71	32,076,531
Wisconsin	674,588	24.29	16,385,743	805,170	17.10	13,772,432
Minnesota	492,117	20.79	10,231,112	617,256	16.49	10,188,617
Iowa	1,331,888	19.79	26,358,064	2,577,161	18.03	46,455,399
Missouri	774,122	18.53	14,344,481	1,515,935	15.98	24,221,922
Kansas	750,815	18.69	14,032,732	1,829,422	16.71	30,563,967
Nebraska	420,069	20.15	8,464,390	1,306,372	17.03	22,242,548
California	268,628	27.75	7,454,427	697,805	16.80	11,719,707
Oregon	88,730	27.31	2,423,216	762,728	17.15	13,079,341
Nevada	18,399	30.00	551,970	373,527	14.53	5,426,224
Colorado	65,563	30.40	1,993,115	1,048,933	16.77	17,595,648
Arizona	16,790	20.00	335,800	604,170	15.00	9,062,550
Dakota	248,619	19.32	4,803,319	822,017	15.79	12,980,555
Idaho	31,750	30.00	952,500	374,247	16.50	6,175,076
Montana	33,015	29.75	982,196	981,786	17.24	16,925,993
New Mexico	20,375	21.25	432,969	1,383,357	11.25	15,560,693
Utah	52,910	22.10	1,169,311	426,170	14.08	5,999,615
Washington	83,641	35.89	3,001,875	369,381	23.51	8,684,635
Wyoming	10,404	32.25	335,529	1,217,890	14.98	18,240,947
Total	15,952,883	22.14	353,152,133	36,849,024	15.21	560,625,137

Estimated number of animals on farms and ranches, total value of each kind, and average price January, 1890.

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	542,248	$2.94	$1,596,920	79,043	$8.41	$664,913
New Hampshire	192,824	2.91	561,311	52,713	9.19	484,299
Vermont	362,112	2.96	1,070,114	77,888	8.60	669,682
Massachusetts	56,530	3.38	190,789	68,580	9.61	658,997
Rhode Island	20,231	3.56	72,073	13,796	9.00	124,163
Connecticut	46,759	3.68	171,956	55,598	9.16	509,503
New York	1,548,426	3.54	5,481,428	686,321	7.27	4,987,014
New Jersey	103,170	4.04	416,807	204,669	8.15	1,668,973
Pennsylvania	945,002	3.36	3,170,671	1,193,415	7.22	8,610,845
Delaware	22,294	3.22	71,798	51,185	5.80	296,873
Maryland	153,763	3.42	526,023	343,079	5.49	1,882,648
Virginia	444,563	2.59	1,151,063	1,009,659	3.60	3,633,764
North Carolina	414,819	1.51	624,718	1,291,893	3.38	4,367,760
South Carolina	102,031	1.86	189,268	670,652	3.95	2,646,125
Georgia	411,846	1.55	640,173	1,627,008	3.31	5,379,540
Florida	110,351	1.99	220,085	358,021	2.42	867,414
Alabama	286,238	1.44	413,613	1,530,001	3.03	4,643,552
Mississippi	240,148	1.50	360,223	1,443,813	2.71	3,919,662
Louisiana	115,082	1.56	179,114	706,947	3.00	2,120,842
Texas	4,752,640	1.52	7,239,696	2,321,246	3.48	8,073,292
Arkansas	269,484	1.49	401,990	1,663,275	2.46	4,091,657
Tennessee	511,118	1.90	968,722	2,242,215	3.54	7,932,059
West Virginia	508,654	2.46	1,251,798	486,226	4.10	1,993.139
Kentucky	805,978	2.73	2,198,708	2,255,102	4.19	9,444,369
Ohio	3,943,589	3.02	11,927,384	2,611,014	5.22	13,619,047
Michigan	2,240,841	3.06	6,858,766	978,755	5.30	5,187,400
Indiana	1,278,000	3.07	3,922,821	2,845,302	5.42	15,435,196
Illinois	688,387	3.04	2,090,287	5,433,250	5.62	30,517,479
Wisconsin	809,009	2.72	2,202,446	1,087,902	5.65	6,141,208
Minnesota	327,375	2.44	800,105	527,526	5.40	2,847,586
Iowa	475,816	2.80	1,330,382	5,805,000	5.94	34,481,700
Missouri	1,198,200	2.09	2,506,754	5,096,000	3.64	18,569,824
Kansas	438,313	1.99	870,271	2,734,195	5.58	15,256,810
Nebraska	239,400	2.10	503,338	2,309,779	5.62	12,985,579
California	4,035,120	2.08	8,409,190	647,000	4.91	3,175,476
Oregon	2,929,830	1.92	5,622,344	270,164	4.27	1,153,059
Nevada	700,986	1.89	1,323,882	19,232	5.30	101,931
Colorado	1,7[illegible],891	2.12	3,778,281	29,508	6.13	180,737

Estimated number of animals on farm and ranches, etc.—Continued.

States and Territories.	Sheep.			Hogs.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Arizona	698,404	$1.65	$1,152,367	20,140	$4.50	$90,630
Dakota	266,329	2.64	703,108	476,569	5.01	2,389,518
Idaho	487,357	2.20	1,072,185	31,000	5.00	155,000
Montana	1,939,845	2.25	4,467,799	29,254	6.80	198,926
New Mexico	3,092,736	1.25	3,872,106	22,593	5.00	113,010
Utah	2,055,900	2.08	4,281,617	47,641	6.86	326,819
Washington	673,060	2.30	1,545,346	143,411	5.48	785,892
Wyoming	1,017,373	2.21	2,249,921	5,200	6.62	34,424
Total	44,336,072	2.27	100,659,761	51,602,780	4.72	243,418,336

DISTRIBUTION OF CATTLE, SHEEP, AND SWINE.

The following table indicates the surprising increase, in fifteen years, of the movement of cattle in Western cities—Chicago, St. Louis, Kansas City, and Omaha. In 1875 the receipts amounted to 1,431,339; in 1889, to 5,219,154, an increment of 265 per cent. Taking out the numbers retained for consumption, the shipments were 1,039,497 in 1885, and 2,530,281 in 1889, an increase of 143 per cent. While the shipments of Chicago were nearly doubled, the consumption, so far as represented by the difference between commercial receipts and shipments, increased from 224,309 to 1,763,310, an enormous advance, caused by the cutting and packing and canning of beef, as well as by the supply of the immediate wants of a rapidly increasing population. The progress of Kansas City in the cattle movement has been more rapid than that of Chicago; and Omaha, a new shipping point, is rising rapidly into prominence. The Missouri River cattle-yards promise to rank above Chicago, and to become the centers of cattle distribution for the country between Missouri and the Sierra Nevadas.

Receipts and shipments of Western markets.

CATTLE.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	920,843	696,534	335,742	216,701	174,754	126,262		
1876	1,096,745	797,724	349,043	220,430	183,378	120,340		
1877	1,033,151	703,402	411,969	251,566	215,768	126,570		
1878	1,083,068	699,108	406,235	261,723	175,344	131,761		
1879	1,215 732	726,903	420 654	226,255	211 415	155,831		
1880	1,382,477	886,614	424,720	228,879	244,709	194,421		
1881	1,498,550	938,712	503,862	293,092	285,863	223,989		
1882	1,582,530	921,009	443,169	188,486	439,671	359,012		
1883	1,878,944	966,758	405,090	249,523	460,780	387,598		
1884	1,817,697	791,884	450,717	315,433	533,526	443,001		
1885	1,905,518	744,093	386,320	233,249	506,627	402,381	114,163	83,233
1886	1,963,900	704,675	377,550	212,958	490,971	370,350	144,457	73,120
1887	2,382,008	791,483	464,828	277,419	669,224	483,372	235,723	151,419
1888	2,611,543	968,385	546,875	333,206	1,056,086	682,622	340,469	206,064
1889	3,023,281	1,259,971	508,190	297,879	1,220,343	744,510	467,340	227,921

The increase between 1875 and 1888 has not been very heavy in Eastern cities. The revolution in the meat trade, caused by the introduction of fresh meat brought in refrigerator cars from the West, has prevented the development of the marketing of cattle on foot. Numbers have decreased 18,256 in Philadelphia, 20,869 in

Boston, and increased only 57,434 in Baltimore, and 58,536 in New York; in all those cities the increase is only 9 per cent.

Receipts at Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	457,057	145,285	152,830	112,679	867,851
1876	467,722	189,989	190,550	110,366	958,627
1877	507,832	155,907	203,470	112,862	980,071
1878	543,587	188,385	188,600	117,675	1,038,247
1879	575,159	183,556	216,780	150,829	1,126,324
1880	679,987	230,079	218,606	138,969	1,267,641
1881	692,570	204,928	225,521	122,174	1,245,193
1882	628,843	130,900	163,300	92,614	1,015,657
1883	674,632	161,162	236,050	94,349	1,166,193
1884	612,976	139,292	154,259	105,002	1,011,529
1885	562,447	112,995	194,644	90,870	960,956
1886	513,470	113,316	176,025	96,357	899,168
1887	498,048	90,584	122,297	85,166	796,495
1888	515,593	124,416	134,574	170,113	944,696
1889	638,937	167,242	....	205,479	....

A gratifying increase in the volume of the movement of sheep in fifteen years is apparent. It illustrates the growing abundance of the meat supply, and indicates a wholesome change in the public taste in favor of mutton. This change is real as a practical fact, but it comes from improvement of mutton more than from any real change in the popular taste. High quality will speedily convert the most perverse mutton-haters, and make the Americans, like the English, mutton-consumers rather than the beef-eaters they are popularly supposed to be. The comparison of receipts and shipments of these primal Western markets is as follows:

	Receipts.	Shipments.
1875	569,954	299,130
1889	2,720,789	1,244,791
Increase	2,150,835	945,661

This is an increase of 377 per cent. in receipts, and of 316 per cent. in shipments. It would be interesting to know how much the average weight of carcass has been increased in the same period.

Receipts and shipments of Western markets.

SHEEP.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	418,948	243,604	125,679	37,784	25,327	17,742	....	....
1876	364,095	195,925	157,831	67,886	55,045	22,460	....	....
1877	310,840	155,354	200,502	87,569	42,190	28,329	....	....
1878	310,420	156,727	168,095	74,433	36,700	30,483	....	....
1879	325,119	159,266	182,648	88,083	61,684	47,782	....	....
1880	335,810	156,510	205,969	93,522	50,611	36,285	....	....
1881	493,624	253,938	334,426	170,395	79,924	61,078	....	....
1882	628,887	314,200	443,120	245,071	80,724	52,652	....	....
1883	749,917	801,630	398,612	217,370	119,665	61,979	....	....
1884	374,463	290,352	380,822	248,545	237,964	105,973	....	....
1885	1,003,598	260,277	362,858	233,391	221,801	115,755	18,985	8,408
1886	1,008,790	266,912	328,985	202,728	172,659	83,234	40,195	17,728
1887	1,360,862	445,094	417,425	287,018	209,956	103,126	76,014	56,444
1888	1,515,014	601,241	456,669	316,676	351,050	169,932	158,503	118,208
1889	1,832,469	711,315	358,495	255,375	370,772	174,851	159,503	103,250

An increase of about 50 per cent. has been made in the Eastern receipts of sheep, which is much greater than the increase of population, showing a larger consumption of mutton than formerly. The

increase in fourteen years has been 53 per cent. in New York, 45 in Boston, 21 in Philadelphia, and 129 in Baltimore.

The shipments are seen to be in relatively large proportions to receipts.

Receipts of Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	1,233,968	372,370	491,500	191,485	2,289,323
1876	1,211,086	348,510	548,850	223,267	2,331,713
1877	1,184,687	346,647	545,870	96,786	2,173,990
1878	1,349,622	372,787	650,400	220,135	2,592,944
1879	1,507,739	479,227	619,450	243,520	2,849,936
1880	1,656,955	476,785	623,494	248,047	3,005,281
1881	1,738,626	505,828	645,792	305,496	3,195,742
1882	2,066,502	626,608	614,000	202,241	3,509,351
1883	2,036,018	648,790	680,417	198,060	3,563,285
1884	2,041,774	628,991	683,546	216,286	3,570,597
1885	1,849,277	639,847	616,573	178,712	3,284,409
1886	1,997,751	524,089	583,579	219,645	3,125,064
1887	2,025,116	591,476	588,279	227,456	3,432,327
1888	1,882,763	538,490	594,612	438,910	3,454,775
1889	1,805,805	540,460	....	421,951	....

The numbers of swine received in four Western markets was 4,604,029 in 1875, and 10,389,971 in 1888, being an increase of 126 per cent. Chicago and Kansas City take the lead, and the rate of advance is greatest in the latter city. Shipments have not increased very rapidly.

Receipts at Eastern cities have increased 59 per cent.

HOGS.

Receipts and shipments of Western markets.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1875	3,912,110	1,582,643	628,569	126,729	63,350	15,790	....	....
1876	4,190,006	1,131,635	877,160	232,876	153,777	26,264	....	....
1877	4,025,970	951,221	896,319	314,287	192,645	15,973	....	....
1878	6,339,654	1,266,906	1,451,634	528,627	427,777	91,671	....	....
1879	6,448,300	1,692,361	1,762,724	686,099	588,908	208,851	....	....
1880	7,059,355	1,394,990	1,840,684	770,769	676,477	152,920	....	....
1881	6,474,844	1,289,679	1,672,153	389,909	1,014,304	195,524	....	....
1882	5,817,504	1,747,722	846,228	261,584	963,036	191,325	....	....
1883	5,640,625	1,319,392	1,151,785	609,338	1,379,401	313,879	....	....
1884	5,351,967	1,392,615	1,474,475	678,874	1,723,586	590,133	....	....
1885	6,937,535	1,797,446	1,455,535	789,487	2,358,718	801,162	130,867	71,919
1886	6,718,761	2,090,784	1,264,471	530,362	2,264,484	538,005	390,487	187,369
1887	5,470,952	1,812,001	1,052,240	324,745	2,423,262	524,492	1,011,706	140,726
1888	4,921,712	1,751,829	929,230	294,869	2,008,984	413,937	1,283,600	333,228
1889	5,988,526	1,786,659	1,120,930	420,310	2,073,910	331,434	1,206,605	179,916

Receipts of Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1875	1,388,517	331,989	243,300	279,631	2,243,437
1876	1,222,657	361,317	289,900	259,064	2,132,938
1877	1,268,596	330,604	242,400	322,945	2,164,545
1878	1,794,539	510,432	282,060	260,514	2,847,545
1879	1,725,537	582,615	341,450	356,524	3,006,126
1880	1,719,137	691,839	346,960	336,867	3,094,803
1881	1,533,526	708,900	367,876	338,551	2,948,853
1882	1,366,848	816,535	186,800	268,811	2,638,994
1883	1,586,243	771,757	383,312	271,148	3,012,460
1884	1,697,430	785,261	311,404	282,664	3,076,759
1885	1,919,063	790,332	326,456	265,381	3,301,232
1886	1,980,656	930,787	333,849	323,643	3,568,935
1887	1,791,531	1,039,692	329,561	504,619	3,665,403
1888	1,549,837	1,063,827	344,719	613,959	3,572,342
1889	1,761,623	1,143,314	....	702,966	....

FOREIGN AGRICULTURAL EXCHANGES.

There are presented here in detail from the records of the exports and imports of the Treasury Department the values of surplus products sent to foreign countries, and of the agricultural products imported from other countries. It should be remembered that the prices of exports are not those which are received by farmers, but the values at the sea-port from which they are shipped, which are in some cases more than double the farm prices. The values of imports are given at foreign ports, and are increased by transportation, commissions, and exchanges.

Imports of agricultural products, 1888 *and* 1889.

IMPORTS.

Articles.	1888.	1889.
Sugar and molasses:		
Sugar	$74,245,206	$88,543,971
Molasses	5,491,095	4,753,897
Sugar drainings	7,513	4,026
Total sugar and molasses	79,743,814	93,301,894
Tea, coffee, and cocoa:		
Tea	13,360,685	12,654,640
Coffee	60,507,630	74,724,882
Cocoa	2,251,773	2,142,061
Unenumerated items	312,301	337,739
Total tea, coffee, and cocoa	76,432,389	89,859,322
Animals and their products, except wool:		
Cattle	875,998	703,469
Horses	5,405,863	4,868,862
Sheep	1,366,320	1,259,000
All other and fowls	358,204	392,712
Bristles	1,215,325	1,284,724
Butter	26,429	24,577
Cheese	1,214,936	1,135,184
Eggs	2,312,478	2,418,976
Glue	495,502	454,460
Grease	164,439	212,198
Hair	2,303,485	2,585,941
Hides	23,939,339	25,127,750
Hide cuttings, etc	347,721	232,251
Hoofs, horns, etc	306,120	303,575
Meats—		
Preserved	317,235	329,411
All other	154,619	199,734
Milk, preserved or canned	376,062	85,485
Oil, animal	3,744	3,677
Sausage skins	320,716	377,750
Unenumerated items	141,866	263,278
Total animals and their products, except wool	41,646,401	42,263,014
Fibers:		
Animal—		
Wools	15,887,217	17,974,515
Silk, unmanufactured	19,931,682	19,383,229
Vegetable—		
Cotton	744,800	1,194,505
Flax	1,802,089	2,070,729
Hemp and all substitutes	6,934,837	9,433,774
Jute	3,377,369	2,853,664
Sisal grass and other vegetable substances	5,430,894	6,110,308
Fibers not elsewhere specified	318,133	483,212
Total fibers	54,427,021	59,453,936
Miscellaneous:		
Breadstuffs—		
Barley	8,076,082	7,723,838
Corn	20,507	1,216
Oats	23,655	10,178
Oatmeal	37,515	56,002
Rye	20	24
Wheat	466,886	119,017

Imports of agricultural products, 1888 *and* 1889—Continued.

IMPORTS.

Articles.	1888.	1889.
Miscellaneous—Continued.		
Breadstuffs—Continued.		
Wheat flour	$13,257	$5,792
Breadstuffs and farinaceous substances not elsewhere specified	1,023,861	1,055,655
Chicory	215,034	216,573
Fruits and nuts	20,502,223	18,746,417
Hay	979,524	1,082,885
Hops	1,017,495	1,155,472
Indigo	2,231,555	2,684,105
Ivory, vegetable	156,533	96,574
Malt, barley	164,585	111,381
Oils, vegetable:		
Fixed or expressed—		
Olive	617,172	696,065
Other	1,297,203	1,108,854
Volatile or essential	1,191,871	1,183,005
Opium	1,789,660	1,454,097
Plants, trees, and shrubs	291,854	325,331
Rice and rice meal	3,012,961	3,499,437
Seed	2,833,421	5,097,223
Spices:		
Ground	187,677	173,668
Unground—		
Nutmegs	603,556	514,883
Pepper	1,823,239	1,578,421
All other	914,773	890,889
Tobacco, leaf	10,870,841	10,868,226
Vanilla beans	842,201	699,903
Vegetables:		
Beans and peas	2,190,137	786,343
Potatoes	3,693,021	321,106
Pickles and sauces	416,958	349,422
All other—		
In their natural state or in salt or brine	715,063	423,124
Prepared or preserved	350,245	389,804
Wines:		
Champagne and other sparkling	3,646,475	4,254,413
Still wines—		
In casks	2,287,062	2,126,548
In bottles	1,402,661	1,325,811
Unenumerated items	119,860	123,187
Total miscellaneous	76,026,693	71,254,894
RECAPITULATION.		
Sugar and molasses	79,743,814	93,301,894
Tea, coffee, and cocoa	76,432,389	89,859,322
Animals and their products, except wool	41,646,401	42,263,014
Fibers, animal and vegetable	54,427,021	59,453,936
Miscellaneous	76,026,693	71,254,894
Total imports of agricultural products	328,276,318	356,133,060

Exports of the products of domestic agriculture, 1888 *and* 1889.

EXPORTS.

Articles.	1888.		1889.	
	Quantities.	Value.	Quantities.	Value.
Animals, living:				
Cattle ... number	140,208	$11,577,578	205,786	$16,616,917
Hogs ... do	23,755	193,017	45,128	356,764
Horses ... do	2,263	412,774	3,748	592,469
Mules ... do	2,971	378,765	2,980	356,333
Sheep ... do	143,817	280,490	128,852	366,181
All other and fowls		42,466		86,141
Animal matter:				
Bones, hoofs, horns and horn tips, strips, and waste		193,176		242,429
Casings for sausages		766,186		510,114
Eggs ... dozen	419,701	66,724	548,750	75,936
Glue ... pounds	356,899	46,773	534,203	72,283
Grease, grease scraps, and all soap stock		924,777		827,876
Hair and manufactures of		311,279		388,731
Hides and skins other than furs		673,322		909,798
Honey		7,579		93,888

Exports of the products of domestic agriculture, 1888 *and* 1889—Continued.

EXPORTS.

Articles.	1888.		1889.	
	Quantities.	Value.	Quantities.	Value.
Animal matter—Continued.				
Oils:				
Lard....................gallons..	930,616	509,514	861,303	$542,897
Other animal.. ....do....	617,737	414,622	558,080	377,919
Provisions, comprising meat and dairy products:				
Meat products—				
Beef products—				
Beef, canned.........pounds..	40,458,375	$3,339,077	51,025,254	4,375,213
Beef, fresh..............do...	93,498,273	8,231,281	137,895,391	11,481,861
Beef, salted or pickled..do....	48,980,269	2,608,479	55,006,399	3,043,324
Beef, other cured.......do....	83,151	8,579	194,036	17,819
Tallow..................do....	92,483,052	4,252,653	77,844,555	3,942,024
Mutton ....do....	224,738	18,641	296,220	25,995
Oleomargarine—				
Imitation butter........do....	1,729,327	212,634	2,192,047	250,605
The oil.... ....do....	30,146,595	3,230,123	28,102,534	2,664,492
Pork products—				
Bacon ....do....	331,306,703	27,187,175	357,377,399	29,872,231
Hams...................do....	44,132,980	4,988,458	42,847,247	4,779,616
Pork, fresh ....do....	63,187	4,423	22,794	1,662
Pork, salted or cured...do....	58,836,966	4,368,691	64,110,845	4,733,415
Lard.. ....do....	297,740,007	22,751,105	318,242,990	27,329,173
Poultry and game	....	25,496	....	9,827
All other meat products	....	915,247	....	876,161
Dairy products—				
Butter.......... .....pounds..	10,455,651	1,884,908	15,504,978	2,568,765
Cheese..................do....	88,008,458	8,736,304	84,999,828	7,889,671
Milk..............................	....	294,806	....	260,590
Wax, bees ....pounds..	78,070	20,554	99,917	23,918
Wool, raw ....do....	22,164	5,272	141,576	23,065
Total value of animals and animal matter	....	109,882,948	....	126,586,103
Bread and breadstuffs:				
Barley......................bushels..	550,884	317,239	1,440,321	853,490
Bread and biscuits ....pounds..	13,948,708	658,589	14,494,880	749,652
Corn ....bushels..	24,278,417	13,355,950	69,592,929	32,982,277
Corn meal .... barrels..	270,613	765,036	312,186	870,485
Oats........................bushels..	332,564	143,284	624,226	245,562
Oatmeal ....pounds..	4,329,293	130,488	10,210,413	273,173
Rye ....bushels..	78,783	50,705	287,252	158,917
Rye flour ....barrels..	2,674	10,068	3,669	13,370
Wheat.......................bushels..	65,789,261	56,241,468	46,414,129	41,652,701
Wheat flour...................barrels..	11,963,574	54,777,710	9,374,803	45,296,485
All other breadstuffs and preparations of, used as food	....	741,150	....	780,549
Total value of bread and breadstuffs..............................	....	127,191,687	....	123,876,661
Cotton and cotton-seed oil:				
Cotton—				
Sea island ....pounds..	7,053,765	1,672,828	6,419,569	1,391,495
Other unmanufactured.....do....	2,257,067,061	221,343,932	2,378,397,100	236,383,775
Cotton-seed oil ....gallons..	4,458,597	1,925,739	2,690,700	1,298,609
Total value of cotton and cotton-seed oil.................	....	224,942,499	....	239,073,879
Miscellaneous:				
Broom corn..............................	....	160,651	....	152,542
Fruits and nuts—				
Apples, dried ....pounds..	11,803,161	812,682	22,102,579	1,201,070
Apples, green or ripe ....barrels..	489,570	1,378,801	942,406	2,249,375
Fruits, preserved—				
Canned	....	834,668	....	915,341
Other	....	58,630	....	52,048
All other, green, ripe, or dried.....	....	397,643	....	621,390
Nuts	....	27,784	....	32,360
Hay ....tons..	18,198	328,819	21,923	388,777
Hops ....pounds..	6,793,818	1,203,060	12,589,262	2,823,832
Oil-cake and oil-cake meal ....do....	562,744,209	6,423,930	588,317,880	6,927,912
Oils—				
Linseed.................gallons..	92,134	52,049	72,451	42,759
Other vegetable..................	....	56,890	....	55,812
Rice ....pounds..	398,535	22,234	439,706	24,124
Seeds—				
Clover ....do....	13,357,899	1,009,695	34,253,137	3,110,583
Cotton.....................do....	6,218,555	84,195	11,373,865	119,279

Exports of the products of domestic agriculture, 1888 *and* 1889—Continued.

EXPORTS.

Articles.	1888.		1889.	
	Quantities.	Value.	Quantities.	Value.
Miscellaneous—Continued.				
Seeds—Continued.				
Flaxseed or linseed......bushels..	37,265	$41,155	....	....
Timothy.................pounds..	2,097,197	117,677	10,200,673	$451,728
All other........................	....	263,968	....	192,914
Tobacco—				
Leaf....................pounds..	249,195,681	21,507,776	211,521,051	18,546,991
Stems and trimmings ......do....	13,487,140	428,308	12,238,181	354,077
Vegetables—				
Onions ....bushels..	56,725	64,161	75,074	63,780
Peas and beans............do....	253,170	462,762	294,456	560,574
Potatoes..................do....	403,880	308,193	471,955	316,224
Vegetables, canned	....	265,537	....	311,254
All other, including pickles........	....	140,634	....	198,120
Wine—				
In bottles ....dozen..	7,185	31,698	7,311	33,000
Not in bottles............gallons..	302,233	201,525	372,359	236,488
All other agricultural products.......	....	263,770	....	228,399
Total value of miscellaneous products..............	....	36,948,895	....	40,210,753
RECAPITULATION.				
Total value of animals and animal matter.	....	109,882,948	....	126,586,103
Total value of bread and breadstuffs	....	127,191,687	....	123,876,661
Total value of cotton and cotton-seed oil .	....	224,942,499	....	239,073,879
Total value of miscellaneous products....	....	36,948,895	....	40,210,753
Total agricultural exports	....	498,966,029	....	529,747,396
Total exports	....	683,862,104	....	730,282,609
Per cent. of agricultural matter	....	73.0	....	72.5

In this compilation of domestic agricultural exports sugar and molasses are not included, because they are mainly re-exports of foreign production. The totals differ from those given by the Bureau of Statistics of the Treasury Department, they having included sugar and molasses, "ginseng and roots, herbs and barks not otherwise specified," and "glucose or grape sugar."

The agricultural exports of the United States during the past year amounted to about $530,000,000 at the sea-ports, or about $400,000,000 on the farms. The agricultural imports amounted to over $356,000,000 at ports of shipment, and fully $400,000,000 with freights and commissions added, without further allowance for undervaluation. Thus it takes most of our agricultural exports to pay for agricultural imports. These imports are largely food and fibers. The heavier items for 1888–'89 were as follows:

Sugar and molasses..	$93,301,894
Animals and their products, except wool..........................	42,263,014
Fibers, animal and vegetable..	59,453,936
Fruits and nuts...	18,746,417
Barley and other cereals..	8,971,722
Tobacco, leaf..	10,868,226
Wines..	7,706,772
Total..	241,311,981

Most of this importation should be produced here, and many minor products not named; in fact, there is little on the list, except tea and coffee, that should be imported. There are many plants yielding fruits, dyes, medicines, and other products useful in the arts or for food that could be profitably grown, after suitable experiments, for the supply of a demand already existing or to be created, and utilizing rural labor and increasing the wealth of the country.

WOOL PRODUCTION IN THE UNITED STATES.

Sheep husbandry has been a great benefaction to rural industry. Its development has been remarkable since 1860. Wool manufacture at that date was in its infancy. Only certain lines of its manufacture were then in existence. Some of its most prosperous branches have had their birth and growth since. The first manufactures were those of the household, domestic manufacture, with very little aid from machinery, which were general and extensive up to 1810, when the total value was estimated at $25,608,788. After the war of 1812, and the embargo on importation was removed, goods came in under low duties, flooding the market and destroying the manufacture, which amounted to only $4,413,068 in 1820. The factory system, as it was gradually perfected in other countries, cheapened the cost of goods, rendering the continuance of domestic production impracticable. The duties were increased in 1824 and 1825 to 25, 30, and 33⅓ per cent., to 40, 45, and 50 by several acts from 1828 to 1830, and to 50 per cent. by the acts of 1832. The result was an increase in production, which advanced with the growth of the country and the development of processes and machinery, very slowly at first, and with many checks from adverse tariff legislation. The war, and inflation of currency which it caused, operated as the highest protection ever known, and afterwards, when a disastrous reduction of values of wool and woolens resulted from previous abnormal production and distribution throughout the world, the tariff of 1867 was enacted, which stayed but did not entirely obviate the destructive effects of low prices upon sheep husbandry, as flocks were reduced by millions during two or three years. As prices advanced after several years of glutted markets, sheep began to increase again, new branches of manufacture were introduced, and a grand development of wool growing and wool manufacturing has crowned the work of a quarter of a century, during which time the advance has been about three times the volume of all the preceding development.

HOME PRODUCTION OF WOOL.

The following table gives the estimated numbers of sheep and pounds of wool since 1870:

Years.	Sheep.		Wool.
	Number.	*Value.*	*Pounds.*
1871	31,851,000	$74,035,837	160,000,000
1872	31,679,300	88,771,197	150,000,000
1873	33,002,400	97,922,350	158,000,000
1874	33,938,200	88,690,569	170,000,000
1875	33,783,600	93,320,652	181,000,000
1876	35,935,300	98,666,318	192,000,000
1877	35,804,200	80,892,683	200,000,000
1878	35,740,500	80,603,062	208,250,000
1879	38,123,800	79,023,984	211,000,000
1880	40,765,900	90,230,537	232,500,000
1881	43,569,899	104,070,861	240,000,000
1882	45,016,224	106,595,954	272,000,000
1883	49,237,291	124,365,835	290,000,000
1884	50,626,626	119,902,706	300,000,000
1885	50,360,243	107,960,650	308,000,000
1886	48,322,331	92,443,867	302,000,000
1887	44,759,314	89,872,839	285,000,000
1888	43,544,755	89,279,926	269,000,000
1889	42,599,079	90,640,369	265,000,000

The increase in numbers of sheep from 1871 to 1884 was about 60 per cent. and that of wool was 88 per cent. Improvement by breeding has doubled the weight of fleece per sheep and improved its quality. The improvement of the preceding twenty-five years was very small in comparison. The above estimates include not only the spring and fall fleece wool, but also that of sheep slaughtered *ad interim*. Thus the amount of wool is always greater than the actual average weight of fleece applied to the numbers of sheep reported in the enumeration.

WOOL IMPORTS.

The imports of wool from the enactment of the tariff to 1883, inclusive, seventeen years, were scarcely 5 per cent. more for the last half of that period than for the first, while the population had increased more than 25 per cent. There was an actual relative decline, considered in relation to numbers of people to be supplied. The injurious effect of the reduction of 1883, small as it appeared to be, is seen in the reduction of eight million sheep in six years, and the first depression of sheep husbandry that has occurred since that which the tariff of 1867 was designed to cure, and which in two years turned the tide of discouragement which was then so severe and so general throughout the world.

As our flocks declined wool importation advanced, and the flow of coin to the purses of our farmers was diverted to the pockets of foreign growers in Australasia, South America, and Asia. For these six years the importation has averaged 100,000,000 pounds per annum, almost double the average of the preceding seventeen years.

SO-CALLED CARPET WOOLS.

An examination of the table which follows, given on authority of the official publications of the Bureau of Statistics of the Treasury Department, will show that about seven-tenths of the entire importation of the last ten years has been admitted under the third class as "carpet wools," a designation very inexact, as it includes the wool of all the races of sheep in the world, improved and unimproved, merino and English only excepted. During the last six years the proportion of this class has been about three-fourths of all. Dividing these imports into two periods—one of the last ten years and the other of thirteen years prior to 1880—the average annual imports of the two periods are thus contrasted:

	Clothing wool.	Combing wool.	Carpet wool.	All wool.
Average, 1869-79	7,111,715	12,528,779	29,057,407	48,697,901
Average, 1880-89	19,305,070	5,654,293	63,484,036	88,443,399

Remarkable changes are exhibited in this statement. The wools of the first-class are increased from 14.6 to 21.8 per cent. of the respective totals of these periods. The second exhibits a still greater change in the other direction, a drop from 25.7 to 6.4 per cent. In 1873 the importation was nearly 50,000,000 pounds of this class. Two-thirds of the entire receipts of thirteen years were admitted in four years, 1871–'74. What is the explanation of this remarkable change? The manufacture of worsted stuffs had become very extensive in response to popular demand. Free combing wools could only come from Canadian or English flocks or those of English blood. The

demand was greater than the supply. What was to be done? The manufacturers are not so helpless under restricted supply of wools of pecular quality as many affect to believe. They invented machinery for combing merino wool, and taking the long staple of Ohio and Michigan grade merinos, they converted it into combing wool so successfully that very little is now imported. Such a result was a stimulus to other inventions, by which the European fabrics of fashion and taste can be duplicated or simulated with marvelous skill, and the wools of one class can be substituted for those of another. The effect is a serious blow to wool growing, as the motive is strong for such improvements as may render possible the use of wools of the third class, admitted at a nominal duty, instead of those costing more and dutiable at the highest rate. It is charged by wool-growers, admitted by some manufacturers, and believed by nearly everybody, that the excessive imports of this class are due to this cause possibly quite as much as to increase of carpet manufacture.

Wools entered for consumption in the United States from 1867 *to* 1889, *inclusive, stated by years for each class, quantity, and value.*

Years.	No. 1. Clothing wool.		No. 2. Combing wool.		No. 3. Carpet and similar wools.		Total pounds.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	
1867	1,270,356	$415,609	150,302	$31,827	36,263,017	$5,332,074	37,683,675
1868	4,681,679	918,588	1,804,272	332,315	18,096,600	2,704,768	24,582,551
1869	2,512,202	505,715	4,533,367	1,092,297	27,650,371	3,653,082	34,695,940
1870	6,530,493	1,249,152	2,752,569	765,147	29,351,006	3,416,024	38,634,068
1871	5,957,461	1,201,201	17,665,600	3,167,835	26,550,995	3,335,638	50,174,056
1872	16,871,332	4,183,960	41,155,460	8,952,131	36,289,141	6,435,468	94,315,933
1873	6,029,488	1,744,200	49,540,231	12,723,501	28,642,863	5,998,465	84,212,582
1874	2,398,210	815,307	27,087,438	6,193,150	27,308,090	4,603,410	56,793,738
1875	13,117,679	3,602,535	7,769,157	2,153,261	30,799,458	4,472,826	51,686,294
1876	8,643,366	2,187,713	3,167,307	1,153,504	28,465,005	4,546,398	40,275,678
1877	9,294,029	2,202,639	2,509,954	830,715	28,310,411	3,979,617	40,114,394
1878	9,916,012	2,431,043	3,028,869	969,683	26,856,280	3,594,640	39,801,161
1879	5,229,987	1,114,301	1,709,601	413,761	33,163,054	3,988,752	40,102,642
Total	92,452,294	22,571,963	162,874,127	38,779,127	377,746,291	56,061,162	633,072,712
Average	7,111,715	1,736,305	12,528,779	2,983,010	29,057,407	4,312,397	48,697,901
1880	26,785,172	6,412,273	13,266,856	3,801,730	59,320,412	7,699,663	99,372,440
1881	20,609,707	4,751,454	4,421,491	1,271,332	42,385,769	6,038,041	67,416,967
1882	13,489,923	3,042,407	2,318,671	648,252	47,208,175	6,642,699	63,016,769
1883	11,546,530	2,567,443	1,373,114	343,987	40,130,323	5,580,558	53,049,967
1884	20,703,843	4,700,605	4,474,396	1,058,758	62,525,692	7,833,936	87,703,931
1885	13,472,432	2,994,533	3,891,914	921,252	50,782,306	5,558,479	68,146,652
1886	23,321,759	4,344,189	4,872,739	1,106,116	79,716,052	8,343,908	107,910,550
1887	23,195,734	4,339,498	9,703,962	2,270,058	81,504,477	9,741,814	114,404,173
1888	16,952,513	3,648,780	5,568,068	1,322,862	74,710,686	9,090,459	97,231,267
1889	22,973,088	4,764,015	6,651,719	1,556,309	96,556,467	11,112,435	126,181,274
Total	193,050,701	41,565,197	56,542,930	14,300,656	634,840,359	77,641,992	884,433,990
Average	19,305,075	4,156,520	5,654,293	1,430,066	63,484,036	7,764,199	88,443,399

This table shows that the wools desired for importation are those that are cheapest. It is the fiber of highest cost, the original combing wool, that is nearly blotted out of the record. The average cost of that for the period of thirteen years was 23.8 cents per pound; for the ten years period, 25.3 cents. The merino class takes the place of the wool of higher cost. That averaged 24.4 cents for the first period, and 21.5 cents for the second, and this is the wool which competes directly with the product of this country. The third class averaged 14.8 cents for the first period, and 12.2 cents for the second.

But there is something more to be said on the carpet-wool question. The increase of this class would be suspicious in itself, but

suspicion is changed into certainty by the known evasions, sophistications, and frauds which are used to beat the customs and introduce a wool of high value, in some cases of more than twice the average value of all wool imported, at about half the duty of the two higher grades. The great range of prices in this class shows the large difference in intrinsic values and in its uses. This range can not be given, but a separation of that costing 12 cents or less per pound from wools of higher cost shows not only a great disparity in price, but a heavy proportion in recent imports of the fiber of higher value—a value only a little lower than the merino wool that is so much in demand and claimed to be so peculiar that it can not be matched or successfully substituted. The quantity and average value of these subdivisions of the carpet-wool importation, since 1883, are as follows:

Years.	Wools costing 12 cents or less.		Wools costing over 12 cents.	
	Pounds.	Cents per pound.	Pounds.	Cents per pound.
1883	28,477,593	12.1	11,652,730	18.4
1884	46,654,102	11.0	15,871,590	16.6
1885	45,073,356	10.1	5,708,950	17.3
1886	71,550,878	9.7	8,165,174	17.1
1887	61,811,967	10.0	19,692,510	18.1
1888	54,703,172	10.1	20,007,514	17.9
1889	75,799,718	10.2	20,756,467	16.4

The present discriminations in favor of the miscellaneous wools of the world, coming in under the convenient and deceptive name of carpet wool, are ample cause for the reduction of our wool supply and the depression of wool growing. By the law of 1883, and especially by its construction in a spirit hostile to wool-growers, a severe blow has been struck, which has stunned and paralyzed an important branch of an industry. Similar hostile legislation and administration would nearly destroy the industry as a whole and compel a search for 100,000,000 pounds, perhaps 200,000,000, in foreign countries. The result would be an advance in wool, which would benefit foreigners and increase the cost of clothing, while our own growers would hesitate to rehabilitate their flocks, in view of their fatal experiences of the past.

There is no question of the possible production of carpet wools in ample variety and of fine wools of all kinds. Climates and soils may produce slight differences, minor peculiarities, but we have a continent that offers climatic conditions in sufficient variety to equip a world, and soils ample to illustrate its geology. A wide belt of the country, from the Atlantic to the Pacific, was long the home of sheep producing carpet wools. It has some now, though the classes not discriminated against have necessarily taken their place in part. The following extract from a letter to the Secretary of Agriculture is a sample of many that mourn the decadence of this branch of wool-growing:

I have read with much interest your letter to the Home Market Club of Boston, on the practicability of producing to advantage all kinds of wool in this country, and I beg to say that our house some years back received millions yearly of the best carpet wools that the world can produce. These wools were raised in Colorado, New Mexico, and other localities. While some of the fleeces were small, much of it was long-staple coarse wool, weighing about 8 pounds per fleece, and had not the harsh working qualities of much of the foreign carpet wool. It would take a better

color in dyeing than the foreign, and was admitted by the large carpet factories to whom we sold it to be superior in every respect for their uses, excepting in price. The duty on clothing wools being so much higher than on carpet wools the grower was forced to cross his sheep with a finer grade, and consequently domestic carpet wool has gradually almost disappeared, and in its place the sections adapted naturally to raising carpet wools are producing a mongrel, poor style of semi-fine wool, called "Improved Territory."

CHEAPNESS CONTROLS IMPORTATION.

A study of these records of imports shows that it is not indispensable quality or peculiarity of fiber, so much as cheapness, that controls importation. When manufacturers can practically blot out of existence the radical difference between carding and combing wool, so as to make combing wool of the very type of the clothing class, the merino, and drive from the market nearly all the wools of English breeds, it is difficult to fix a limit to the substitutions and combinations that are possible. When the imports which include these valuable and indispensable sorts, as they are assumed to be, cost only 14.2 cents per pound for the last fiscal year, against 16.4 cents for the 20,000,000 pounds of best carpet wool, while American wools command a price so much higher, the cause of the large importation of 126,487,729 pounds is explained. While nearly three-fourths of the wool manufactured, even under the present tariff disabilities, is grown in the United States, and paid for at a much higher rate than foreign wool, the latter is preferred when its cheapness touches an extreme point, notwithstanding its lack of uniformity, strength, and practical value.

The growers have been assured that manufacturers favor fair and equal protection for both partners in cloth-making. That is all they want, and at present seem determined to have. In the absence of such equality there seems to be danger of destruction of both branches of the industry.

The following statement, by decades, of the importation, is compiled from the official records of imports:

Net importation of raw wool, 1822 *to* 1887.

Periods.	Aggregate.	Annual average.	Average imports per capita.
	Pounds.	*Pounds.*	*Pounds.*
1822-'30	16,936,307	1,881,812	.2
1831-'40	62,865,275	6,286,528	.4
1841-'50	139,764,592	13,976,459	.7
1851-'60	230,106,287	23,010,629	.9
1861-'70	501,611,132	50,161,113	1.4
1881-'80	640,916,638	64,091,664	1.5
1881-'89	786,862,753	87,429,195	1.5

The average supply since 1840 from domestic and foreign fleece has been as follows:

Total wool resources by decades, average per annum.

Periods.	Product.	Imports.	Total supply.	Per capita supply.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1841-'50	46,000 000	13,976,459	59,976,459	3.0
1851-'60	66,000,000	23,010 629	89,010,629	3.3
1861-'70	150,000,000	50,161,113	200,161,113	5.4
1871-'80	186,275,000	64,091,664	250,366,664	5.7
1881-'89	281,222,222	87,429,195	368,651,417	6.5

SUMMARY OF THE SUPPLY.

The most striking fact which these figures present is that the manufacture, in proportion to the population, has been doubled in fifty years. The rate of consumption has also nearly doubled. People are better clothed as well as better fed, and the advance probably represents fairly the improvement which has accrued in the progress of our civilization, only in many points it would greatly underestimate the contrast between the comforts of life in 1840 and 1890, respectively. Thirty years ago the consumption of wool in both domestic and foreign goods was equal to about 4½ pounds; now it is about 8 pounds. Shoddy and vgetable fibers are not included in either case. The imports of woolen goods, as given in official records, have been as follows:

Periods.	Aggregate.	Annual average.	Average value per head.
Ten years ending—			
1830	$82,900,615	$8,290,062	$0.75
1840	139,507,716	13,950,772	.94
1850	130,058,518	13,005,852	.65
1860	318,332,730	31,232,273	1.16
1870	330,465,214	33,046,521	.94
1880	395,376,936	39,537,694	.90
Nine years ending 1889	377,124,377	41,902,709	.74
Total	1,768,763,106	25,634,291	

It will please all true Americans to see that the proportion of foreign goods per head has been declining since 1860, and amounts to only 74 cents per head. In goods of that cost the value of raw wool can not exceed 40 cents, which would not pay for 2 pounds of wool at the average cost of wool imported into Great Britain.

BEE-KEEPING.

Among the minor branches of rural industry bee-keeping is one of the most important, though its prominence is not generally recognized, from the fact that it is almost everywhere carried on as an incident of general agriculture and but rarely as a leading rural occupation. Every State and Territory reports bees and more or less honey, usually a hive or a few colonies for each farmer rather than extensive apiaries and large production. In some localities, as in portions of New York, Ohio, Tennessee, and California, where existing conditions are particularly favorable, apiculture is more prominent, dominating other industries perhaps in a neighborhood, though very rarely the leading branch of agriculture over any considerable area. The value of the annual product of honey and wax is not generally realized; they are produced more or less extensively in every section of the country, and the aggregate value is large, much larger than that of other crops of which more notice is usually taken. It almost equals the value of the rice or the hop crop, falls but little short of the buckwheat product, exceeds the value of our cane molasses, and of both maple sirup and sugar. It largely exceeds the aggregate value of all our vegetable fibers excepting cotton, and in 1879 was half as large as the wine product of the year.

The latest official record of production by States is the return of the national census for the year 1879. It made the honey production 25,743,208 pounds, and wax 1,105,689 pounds. After careful study of all available data of local values and market prices, the average farm value of the honey was estimated at 22 cents per pound, and the wax at 33 cents, making the aggregate value of apiarian products, at the place of production, $6,028,383. The product of the principal States in that year was as follows:

States.	Honey.	Wax.	States.	Honey.	Wax.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
Tennessee	2,130,689	86,421	Illinois	1,310,806	45,640
New York	2,088,845	79,756	Iowa	1,310,138	39,565
Ohio	1,626,847	56,333	Virginia	1,090,451	53,200
North Carolina	1,591,590	126,263	All other	11,678,184	524,984
Kentucky	1,500,565	46,912			
Pennsylvania	1,415,093	46,610	Total	25,743,208	1,105,689

Under the head of "all other," in the above statement, there is grouped the production of thirty-six States and Territories, ranging from 1,056,034 pounds of honey in Georgia to 50 pounds in Idaho.

The census of 1870 was defective in its returns of product for many crops, and its record of honey and wax in 1869 is undoubtedly much too low. It made the honey product only 14,702,815 pounds, too low in the aggregate, though the falling off in all States indicates that it was a year of short production. Illinois was the leading State, with a crop of 1,500,000 pounds, while North Carolina stood second. The returns in 1860 were more satisfactory, and they show that the product of 1859 was but slightly exceeded by the crop of 1879, after twenty years of growth. The production of wax was actually greater. Many States show a product greater than that of 1879, and the aggregates of 23,366,357 pounds of honey and 1,322,787 pounds of wax indicate that there has been a comparative decline of the industry, the increase of population being taken into consideration. The nine States given in the preceding table as those of principal production in 1879 produced 14,000,000 pounds; the same States twenty years earlier had a record of 13,900,000 pounds. With our rapid annual increase of population, to stand still in aggregate production is to retrograde. A more striking way of showing the decline in the industry is by a study of the comparative supply of the product at widely separated periods.

Our foreign trade in honey has never been large, and the balance has fluctuated. During five years past our average annual exportation has been valued at only $82,489 and importation at $52,891, making the value of the net exportation only $29,598. This little exportation goes principally to the United Kingdom, France, and Germany, while our foreign purchases come mainly from the West Indies and Mexico. The balance of trade is too small to affect the supply, and our domestic consumption is satisfied with our home production. In 1859 our production was 23,366,357 pounds, and our net importation not far from 3,000,000 pounds, making the supply available for consumption that year approximate 26,000,000 pounds. On the basis of the population June 30, 1860, this was a per capita supply of eight-tenths of a pound. Twenty years later, when tremendous advances had been made in almost every branch of industry, the production of honey only amounted to 25,743,208 pounds,

and the official records actually show a net exportation of honey, or something shipped as honey, amounting to about 570,000 pounds, making the net supply available about 25,000,000 pounds, or a million pounds less than at the first period. The supply per head was less than five-tenths of a pound. During the same period the per capita consumption of sugar and other sweets increased. Wealth and the ability to gratify taste for luxuries are greater, and yet the data seem to show a reduced consumption of this luxurious sweet. So anomalous does this appear that some explanation must be found. If the supply per individual unit had been the same in the last period as the first, it would have required a product of 40,000,000 pounds. What has taken the place of honey in domestic consumption? Does the enormous increase in the manufacture of glucose and other saccharine adulterants indicate that a fraudulent article makes up the remainder of the needed supply? Did our people in 1879 consume 15,000,000 pounds of substitutes in the belief that they had the genuine product of the hive? Such would be a reasonable explanation of the comparative decline in bee-keeping.

FOREIGN TRADE AND THE AMERICAN SURPLUS.

The statistical branch of official work of the Department of Agriculture has been engaged for several years in perfecting its international exchanges, and utilizing, as far as circumstances permitted, the facts of production, distribution, and consumption, to show our producers the probable European supply or relative deficiency of products of which the United States has usually a surplus that is wont to seek a foreign market. Our monthly reports have contained comprehensive data of this sort that could not be obtained elsewhere. The work is appreciated by American farmers, and has been amplified from their suggestion, though it was initiated before any public demand had been made for it.

In attempting to show the requirements of countries deficient in food supplies, as well as to indicate the surplus which some of them may be able to spare, the records of imports or exports of a single year will not answer, as annual fluctuations are the rule, and they are often so wide as to mislead very intelligent readers.

The records of ten consecutive years will give the average deficiency or surplus of each country, and correct the crude impression derived from the figures of a single year. In the tabular statements here given the compilation is for ten years, when the annual official statements were available for so long a period. The work is one of greater difficulty than any one not thoroughly familiar with its intricacies could imagine. Not only has each country a different language, but different weights and measures and different monetary denominations. At the same time there is a great variety in the methods of tabulation and arrangement, and wide differences in the date of publication of annual statements. These and other hindrances demand patient and persistent labor and lynx-eyed vigilance to avoid mistakes. It may be too much to hope that absolute accuracy has been obtained, though the work has been done in duplicate and all discrepancies tested and eliminated. The monetary equivalents are those authorized by the United States Treasury Department, and those of weights and measures accord with the standard authorities.

The following table shows how nearly Europe supplies her requirements for consumption in cereals and dairy products. Wheat and rice are the only cereals that have any serious balance against them. There is no exportation of cotton and little of wool.

Net imports and exports of European countries.

Products.	Net imports.		Net exports.	
	Quantity.	Value.	Quantity.	Value.
Wheat....bushels..	203,212,579	$271,009,265	88,004,189	$110,294,156
Wheat flour....barrels..	7,463,445	48,292,260	954,278	5,997,950
Corn....do....	88,669,855	63,139,861	31,522,863	18,031,997
Oats....bushels...	86,503,335	42,055,806	67,529,323	36,012,986
Barley....do....	54,025,054	41,214,014	45,987,686	32,741,348
Rye....do....	53,858,031	46,380,044	52,553,697	47,432,091
Rice....pounds..	1,130,083,518	30,216,233	61,615,703	2,638,368
Potatoes....bushels..	13,594,588	9,204,243	15,292,093	6,754,409
Butter....pounds..	247,334,200	55,070,449	225,563,301	42,145,207
Cheese....do....	252,881,289	30,434,817	113,502,046	11,435,316
Tobacco....do....	324,053,166	51,659,509	....	....
Cotton....pounds..	2,635,789,404	341,370,742	....	....
Wool....do....	827,160,179	181,196,360	45,513,855	2,541,520

The record by countries is interesting, but for want of space can not be given here, excepting only wheat, cotton, wool, and tobacco. The tabulations may be found entire in report No. 62, new series, of the reports of the Statistician.

WHEAT

The possibilities of the wheat trade are limited. It is a dictate of national prudence, if not a necessity of national existence, that every country should provide its own bread. The bread of Asia, Africa, and the islands of the sea is not made from wheat, as a rule, and we never can have a demand for wheat from those distant regions. Europe is practically our only market, with 350,000,000 people, producing an average of about 1,200,000,000 bushels, purchasing from other continents about 144,000,000 bushels per annum in grain and flour, and thus using nearly 4 bushels per head, of which nearly half a bushel is imported, a quantity equal to the annual requirement for seeding the domestic area occupied in European wheat growing. No amount of advertising, no proffers of reciprocal trade, no change of fiscal policy can force upon Europe another peck per capita, scarcely another quart, for many years to come, unless some unexpected disaster shall befall her domestic crops. The small deficiency exists now only in the countries of western Europe, and mainly in Great Britain. If the surplus of eastern Europe should be distributed only in continental countries it would nearly supply all deficiencies, leaving practically only Great Britain to receive the imports of other continents, to consume alone the surplus of the wheat markets of the world.

There is no material decline that appears to be permanent in European production. The crop of 1886 was a small one, and that of 1885 slightly below the average; the last two harvests were larger than those of 1880, 1881, and 1883. The following annual aggregates are from official figures, supplemented by commercial estimates in the case of nations issuing no annual official estimates:

Years.	Bushels.	Years.	Bushels.
1880	1,123,409,841	1886	1,108,051,514
1881	1,159,816,355	1887	1,245,191,381
1882	1,232,617,880	1888	1,240,379,925
1883	1,152,951,680		
1884	1,270,324,890	Average	1,195,709,023
1885	1,182,637,753		

The last aggregate, that of 1889, so far as is now determined, is only 1,119,495,627 bushels. The average represents a wheat supply almost sufficient for the wants of Europe, about twice as much as is produced in North and South America, and more than half of all that is grown in the world.

The totals in these tables "for foregoing European countries" are the sums of the net imports and exports, not including Canada and the United States. The purpose of this summation is to present the net result for European countries, so far as their records of imports and exports are quotable, separated from the figures for America. A glance at these totals—a subtraction of net exports from net imports—will show the average deficiency supplied by America or other continents.

Quantity of wheat.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
		Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
Austria-Hungary	1877-'86	6,544,796	9,981,258	....	3,436 462
Belgium*	1877-'86	22,510,487	7,452,369	15,058,118	....
Canada	1877-'86	1,564,211	3,722,974	....	2,158,763
Denmark	1877-'86	1,825,577	869,269	956,308	....
France	1877-'86	43,894,546	783.643	43,110,903	....
Great Britain and Ireland	1877-'86	104,682,320	2,234,480	102,447,840	....
Germany	1877-'86	23,640,176	9,400,359	14,239,817	....
Italy	1877-'86	14,088,754	2,077,307	12,011,447	....
Netherlands	1877-'86	16,314,746	8,481,203	7,833,543	....
Norway	1877-'86	233,810	....	233,810	....
Portugal	1877-'86	3,225,341	....	3,225,341	....
Roumania	1879-'85	....	13,144,984	....	13,144,984
Russia in Europe	1877-'85	....	71,422,743	....	71,422,743
Spain	1877-'86	4,095,452	....	4,095,452	....
United States	1877-'86	688,853	95,997,613	....	95,308,760
Total for foregoing European countries	....	....	....	203,212,579	88,004,189

Value of wheat.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
Austria-Hungary	1877-'86	$7,223,317	$13,247,941	....	$6,024,624
Belgium*	1877-'86	29,991,575	10,098,824	$19,892,751	....
Canada	1877-'86	1,648,251	3,979,598	....	2,331,347
Denmark	1877-'86	2,273,526	1,083,613	1,189,913	....
France	1877-'86	64,477,412	1,224,357	63,253,055	....
Great Britain and Ireland	1877-'86	137,503,562	2,921,052	134,582,510	....
Germany	1877-'86	28,989,304	12,808,137	16,181,167	....
Italy	1877-'86	17,718,037	2,848,178	14,869,859	....
Netherlands	1877-'86	23,113,754	12,015,659	11,098,095	....
Norway	1877-'86	304,475	....	304,475	....
Portugal	1877-'86	4,210,164	....	4,210,164	....
Roumania	1879-'85	....	12,423,290	....	12,423,290
Russia in Europe	1877-'86	....	91,841,242	....	91,841,242
Spain	1877-'86	5,427,276	....	5,427,276	....
United States	1877-'86	712,904	107,080,311	....	106,367,407
Total for foregoing European countries	....	....	....	271,009,265	110,294,156

* Including spelt and maslin.

The average value of the net imports of wheat, as given in this table, for the period of ten years, from 1877 to 1886, inclusive, is $1.33 per bushel. About one-half of these imports were received by Great Britain.

Quantity of wheat flour.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
		Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Canada	1877–'86	318,615	397,035	....	78,420
Denmark	1877–'86	18,730	514,019	....	495,289
France	1877–'86	290,815	342,821	....	52,006
Great Britain and Ireland	1877–'86	7,020,214	107,349	6,912,865	....
Netherlands	1877–'86	336,404	89,969	246,435	....
Spain	1877–'86	....	406,983	....	406,983
Sweden	1877–'85	348,270	44,125	304,145	....
United States	1877–'86	4,706	7,000,249	....	6,995,543
Total for foregoing European countries	....	....	....	7,463,445	954,278

Value of wheat flour.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
Canada	1877–'86	$1,542,777	$2,049,408	....	$506,631
Denmark	1877–'86	93,098	2,924,241	....	2,831,143
France	1877–'86	1,784,687	2,426,359	....	641,672
Great Britain and Ireland	1877–'86	44,312,379	627,123	$43,685,256	....
Netherlands	1877–'86	3,606,905	964,639	2,642,266	....
Spain	1877–'86	....	2,525,135	....	2,525,135
Sweden	1877–'85	2,244,947	280,209	1,964,738	....
United States	1877–'86	25,749	38,976,193	....	38,950,444
Total for foregoing European countries	....	....	....	48,292,260	5,997,950

The value per barrel of the net imports of flour, as presented in this table, is $6.47 for the period.

COTTON.

The net imports of cotton into European states were equal to nearly four-fifths of the volume of the last crop of the United States, while the exports from this country were equal to seven-tenths of all imports of European countries. The receipts of Great Britain were more than those of all the other countries. Germany, Russia, France, and Spain follow in order. This country is only exceeded by Great Britain in cotton manufacture, and should, ere many decades pass, attain the first rank. There has recently been a greater relative advance in consumption of cotton in continental countries than in Great Britain. The estimated actual consumption of cotton for five years ended in 1888–'89, according to Ellison, of Liverpool, averages 1,466,709,000 pounds for Great Britain and 1,460,055,000 pounds for the Continent. His estimates of the consumption of the United States for the same time average 946,000,000 pounds, and the increase is 41 per cent., reaching 1,074,000,000 pounds in 1888–'89.

Quantity of cotton.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Austria-Hungary	1877-'86	176,435,968	18,260,592	158,175,376	
Belgium	1877-'86	48,522,985		48,522,985	
Canada	1877-'86	17,592,078		17,592,078	
Denmark	1877-'86	961,640	911,033	50,607	
France	1877-'86	300,153,424	80,645,370	219,508,054	
Germany	1877-'86	370,518,480	59,776,384	310,742,096	
Great Britain and Ireland	1877-'86	1,588,122,771	210,522,962	1,377,599,809	
Italy	1877-'86	116,150,674	32,129,620	84,021,054	
Netherlands	1877-'86	89,968,976	64,393,059	25,575,917	
Norway	1877-'86	4,849,459		4,849,459	
Portugal	1877-'86	7,690,968		7,690,968	
Russia in Europe	1877-'86	229,451,574		229,451,573	
Spain	1877-'86	97,988,297		97,988,297	
Sweden	1877-'85	21,239,973		21,239,973	
Switzerland	1877-'86	50,373,236		50,373,236	
United States	1877-'86	4,230,932	1,854,810,035		1,850,579,103
Total for foregoing European countries				2,635,789,404	

Value of cotton.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
Austria-Hungary	1877-'86	$17,513,134	$1,503,296	$16,009,838	
Belgium	1877-'86	6,339,869		6,399,869	
Canada	1877-'86	1,865,988		1,865,988	
Denmark	1877-'86	133,419	126,872	6,547	
France	1877-'86	37,907,227	10,339,454	27,567,773	
Germany	1877-'86	44,306,151	7,171,035	37,135,116	
Great Britain and Ireland	1877-'86	195,882,056	23,157,984	172,724,072	
Italy	1877-'86	14,544,557	4,048,908	10,495,649	
Netherlands	1877-'86	9,843,292	7,045,030	2,798,202	
Norway	1877-'86	585,768		585,768	
Portugal	1877-'86	872,100		872,100	
Russia in Europe	1877-'86	44,226,719		44,226,719	
Spain	1877-'86	13,668,511		13,668,511	
Sweden	1877-'85	2,726,483		2,726,483	
Switzerland	1885-'86	6,154,095		6,154,095	
United States	1877-'86	732,924	202,568,337		201,835,413
Total for foregoing European countries				341,370,742	

WOOL.

Europe draws from South America, Asia, Africa, and Australasia large supplies of wool, from two to three times as much as the annual clip of the United States. The undeveloped countries grow more wool than they use. No country in Europe, however, Great Britain excepted, imports half as much wool as the United States, notwithstanding its continental area and large capacity for wool-growing. This table makes the average net imports of countries deficient in wool supply 827,160,179 pounds, and the net exports of Russia, Roumania, Spain, and Denmark 45,513,855 pounds, indicating a net deficiency in Europe of 781,646,324 pounds.

The Statistician, in his report of the sheep and wool of the world in 1873, made the production 1,926,750,000 pounds from 584,750,000

sheep. Dr. Neumann-Spallart, for 1883–'84, in *Uebersichten der Weltwirthschaft*, made the production of Europe 320,000,000 kilograms, and of the remainder of the world 580,000,000 kilograms, a total of 900,000,000 kilograms, or 1,984,140,000 pounds. In the distribution of this volume he made the consumption of America 170,000,000 kilograms, and of Europe 702,000,000 kilograms, a total of 872,000,000, or 1,922,411,200 pounds, without any records for Spain. Recent official publications for the consumption of 1887 make the same total, with some changes in consumption, in kilograms of $2\frac{1}{5}$ pounds (2.2046), as follows:

France	190,000,000
Great Britain	180,000,000
United States	170,000,000
Germany	140,000,000
Russia (in Europe)	80,000,000
Austria-Hungary	40,000,000
Belgium	40,000,000
Italy	32,000,000
Total (without Spain)	872,000,000

Australia leads in production, followed by the United States, the Argentine Republic, Russia, Great Britain, France, Spain, Uruguay, etc.

We see that the importation into Europe is a little larger than the production; more than half the wool manufactured is from other parts of the world. In this country about three-fourths of the amount manufactured is produced within the boundaries of the United States. There is this difference between Europe and America—the former manufactures more than is used at home, the latter less. The aim of the wool-grower of this country is to supply the home manufacturer if possible; never to export raw wool. If there ever shall be a surplus it will bring more money to the wool-grower if sent abroad in the manufactured form.

Quantity of wool.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Austria-Hungary	1877–'86	47,114,505	23,012,034	24,105,471	....
Belgium	1877–'86	101,044,798	5,953,291	95,091,507	....
Canada	1877–'86	7,717,031	1,940,329	5,776,702	....
Denmark	1877–'86	2,278,839	4,393,194	....	2,114,355
France	1877–'86	336,560,715	32,026,926	304,533,789	....
Germany	1877–'86	191,302,137	33,874,870	157,427,267	....
Great Britain and Ireland	1877–'86	475,377,651	269,095,095	206,282,556	....
Italy	1877–'86	19,913,050	....	19,913,050	....
Netherlands	1877–'86	30,108,443	24,788,963	5,319,480	....
Norway	1877–'86	889,336	....	889,336	....
Portugal	1877–'86	5,966,970	1,756,228	4,210,742	....
Roumania	1879–'85	....	6,591,953	....	6,591,953
Russia in Europe	1877–'86	24,539,499	51,700,819	....	27,161,320
Spain	1877–'86	....	9,646,227	....	9,646,227
Sweden	1877–'85	3,458,326	....	3,458,326	....
Switzerland	1877–'86	5,928,655	....	5,928,655	....
United States	1877–'86	73,019,041	4,327,551	68,691,490	....
Total for foregoing European countries	....	....	....	827,160,179	45,513,855

Value of wool.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
Austria-Hungary	1877-'86	$14,133,568	$8,413,751	$5,719,817	....
Belgium	1877-'86	23,882,306	2,689,573	21,192,733	....
Canada	1877-'86	1,436,712	477,916	958,796	....
Denmark	1877-'86	556,120	698,699	....	$142,579
France	1877-'86	62,571,219	7,325,354	55,245,865	....
Germany	1880-'86	47,960,332	10,232,266	37,728,066	....
Great Britain and Ireland	1877-'86	118,672,277	72,918,380	45,753,897	....
Italy	1877-'86	6,169,921	....	6,169,921	....
Netherlands	1877-'86	5,517,892	5,036,015	481,877	....
Norway	1877-'86	276,951	....	276,951	....
Portugal	1877-'86	833,900	224,824	609,076	....
Roumania	1879-'85	....	865,633	....	865,633
Russia in Europe	1877-'86	14,609,860	9,707,162	4,902,698	....
Spain	1877-'86	....	1,533,308	....	1,533,308
Sweden	1877-'85	1,280,415	....	1,280,415	....
Switzerland	1885-'86	1,835,044	....	1,835,044	....
United States	1877-'86	11,404,222	741,011	10,663,211	....
Total for foregoing European countries	....	....	....	181,196,360	2,541,520

TOBACCO.

The product of tobacco in Europe is nearly equal in quantity to the average production of the United States. Neumann-Spallart has usually made it about 500,000,000 pounds. Austria-Hungary produces about one-third of it, Russia one-tenth, Germany nearly as much, France about 35,000,000 pounds, and the other countries a small quantity. The importations of ten years past, as given in the table, are about two-thirds as much as the production, and a large proportion comes from the United States. Europe can easily produce all the tobacco required, but two reasons are prominent for importation of tobacco from this country. It is very cheap, and it is very desirable for mixing with and fortifying European leaf. If it becomes dearer, a smaller quantity is purchased; if very much dearer, it would scarcely find sale at all. The production is regulated and limited by governmental edicts. Our exportation is not increasing; the proportion of our crop exported is declining, and will continue to fall off as our population increases. Much the larger portion was formerly exported; now the larger part is annually manufactured. For instance, the manufacture of 1888 (calendar year) amounted to 253,000,000 pounds in round numbers (without scraps and stems); the exports to 204,000,000 pounds.

Quantity of tobacco.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
		Pounds.	Pounds.	Pounds.	Pounds.
Austria-Hungary	1877-'86	26,724,668	12,438,221	14,286,447	....
Belgium	1877-'86	21,145,331	131,105	21,014,226	....
Canada	1877-'86	10,780,586	46,674	10,733,912	....
Denmark	1877-'86	7,219,986	148,483	7,071,503	....
France	1877-'86	56,572,911	655,561	55,917,350	....
Germany	1877-'86	90,646,759	7,143,345	83,503,414	....
Great Britain and Ireland	1877-'86	61,866,373	8,724,984	53,141,389	....
Italy	1877-'86	35,766,549	....	35,766,549	....
Netherlands	1677-'86	32,356,914	5,768,997	26,587,917	....
Norway	1877-'86	4,383,847	....	4,383,847	....
Russia in Europe	1877-'86	3,235,169	....	3,235,169	....
Sweden	1877-'85	7,508,550	....	7,508,550	....
Switzerland	1877-'86	11,686,805	....	11,686,805	....
United States	1877-'86	10,772,181	252,899,123	....	242,126,942
Total for foregoing European countries	....	....	....	324,053,166	....

Value of tobacco.

Countries.	Period.	Imports.	Exports.	Net imports or exports.	
				Imports.	Exports.
Austria-Hungary	1877–'86	$5,033,941	$698,202	$4,335,739	....
Belgium	1877–'86	3,077,127	19,364	3,057,763	....
Canada	1877–'86	1,114,431	3,281	1,111,150	....
Denmark	1877–'86	890,109	18,050	872,059	....
France	1877–'86	5,544,810	42,225	5,502,585	....
Germany	1877–'86	13,135,934	626,749	12,509,185	....
Great Britain and Ireland	1877–'86	9,297,628	1,254,556	8,043,072	....
Italy	1877–'86	3,908,076	....	3,908,076	....
Netherlands	1877–'86	2,950,077	525,977	2,424,100	....
Norway	1877–'86	619,884	....	619,884	....
Russia in Europe	1877–'86	2,891,050	....	2,891,050	....
Spain	1877–'85	4,933,402	....	4,933,402	....
Sweden	1877–'85	1,489,514	....	1,489,514	....
Switzerland	1885–'86	1,073,080	....	1,073,080	....
United States	1877–'86	5,506,000	22,271,595	....	$16,765,595
Total for foregoing European countries		....	....	51,659,509	....

THE POSSIBILITIES OF AGRICULTURAL EXPORTATION.

About one-tenth of our agricultural products is exported. No other nation exports so large a proportion. Yet the articles shipped abroad are few. They are cotton, tobacco, meats, breadstuffs, and cheese. All other articles together are but 3 per cent. of the exports. Seven-tenths of the cotton product seeks foreign markets; the quantity can not be increased except to meet the slowly augmenting demand for cotton goods throughout the world, which is at a rate much slower than the growth of agricultural population in the cotton States. The exportation of tobacco is not increasing materially or so rapidly as home consumption, and it can only be enlarged by a reduction in price. The exports of wheat go mostly to one nation, and can not be greatly enlarged. Enlargement of the surplus must inevitably reduce the price of wheat and flour, both at home and abroad.

What other products can be exported? It is folly to look to foreign nations for a market of any of the bulky products of agriculture which are common to the agriculture of every nation. The more concentrated products may be profitably exported. More cheese could be sold if its reputation for quality should be kept up and there were more disposition to cater to fastidious or peculiar foreign tastes. Butter exports could be enlarged if they were of better quality. Evaporated or preserved fruits, oranges of the Southern or Pacific coasts, wines from California, may seek a profitable market as surplus stocks, as a safety-valve to the home market. It should be the policy of all agricultural organizations to promote variety of production, first to tempt new demands for domestic consumption, and ultimately to enlarge the list of exportable products. In this way, though the increased demand will ever come mainly from enlargement of home population, a great variety of surplus goods sent abroad will keep values steady and produce an acceptable enlargement of rural revenue.

What agricultural products are now imported that our country and climate are capable of producing? In response to this inquiry, sugar is the first to be suggested. Our wheat and flour sold will scarcely pay for the sugar bought in the present and immediate future, and the

home demand would not be uncertain, but peremptory and insatiate. Flax and hemp should be more extensively grown, displacing foreign fibers costing millions of money, and furnishing material for bagging of cotton, wool, and hops. Other fibers of subtropical regions should be produced along the Gulf coast. The imported fibers, with their manufacture, altogether amount to a value more than two-thirds as much as the munificent and boasted cotton exportation of the United States. There is an importation of fruits of the value of $20,000,000, most of which should be produced in this country. The subject is too large for treatment in a few paragraphs or pages, but these suggestions mark the lines on which production in this country should be extended, with reference first to the wants of a population growing beyond all foreign precedent, and next to incidental exportation mainly of extended or manufactured products, as a source of additional revenue and as a regulator and upholder of home prices.

DISTRIBUTION OF CORN AND WHEAT.

CORN.

The amount of corn consumed or distributed of the crop of 1889 up to March 1 of 1890 is large, but not equal to the consumption of the previous year. The aggregate of local estimates is 1,143,000,000 already used, leaving a stock on hand of 970,000,000 bushels, or nearly 46 per cent. of the crop. This is a larger remainder than has ever before been reported. The average of eight annual returns is 677,000,000 bushels. The natural growth of the country requires 2 or 3 per cent. increase annually. The comparison of stock on hand and quantity consumed, as heretofore reported on the 1st of March, is as follows:

Date.	Product.	On hand March 1.	Per cent.	Consumed or distributed.
March 1—	*Bushels.*	*Bushels.*		*Bushels.*
1883	1,617,000,000	587,000,000	36.3	1,030,000,000
1884	1,551,000,000	512,000,000	33.	1,039,000,000
1885	1,795,000,000	675,000,000	37.6	1,120,000,000
1886	1,936,000,000	773,000,000	39.9	1,163,000,000
1887	1,665,000,000	603,000,000	36.2	1,062,000,000
1888	1,456,000,000	508,000,000	34.9	948,000,000
1889	1,988,000,000	787,000,000	39.6	1,201,000,000
1890	2,113,000,000	970,000,000	45.9	1,143,000,000

The section which produces the larger part of the crop, the Western, also consumes the largest proportion at this date, leaving out of the account the insignificant quantities grown in the Eastern and in the Pacific coast States. About 65 per cent. of the product is usually distributed in the Western States, but this year only 53.7 per cent. is reported, a portion far below the usual consumption. This marks the present year as altogether exceptional in this respect. It also accounts for the reduction in value, which is recorded elsewhere, since the December returns of value were made.

On the contrary, the consumption of corn in the cotton States is always less in proportion at this date, because the crop matures later and the winter is milder, but especially on account of the comparative absence of feeding for beef and the necessity of general and late feeding of "plow stock" in the spring and summer cultivation

of corn and cotton. A considerable share of the corn crop must be reserved for use after April and until July, by far the busiest season of the year for horses and work cattle.

The details of this consumption, year by year, in the principal groups of States, can be studied in the following record:

Sections.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
New England	70.2	66.2	62.9	61.6	63.3	65.4	66.5	66.4
Middle	62.6	68.2	63.4	59.3	61.8	65.6	62.0	59.9
Southern	56.5	58.6	58.6	54.6	58.1	55.5	55.7	53.5
Western	66.2	69.3	63.3	61.6	65.6	69.6	61.4	53.7
Pacific	74.6	70.7	60.4	68.4	70.5	78.3	75.1	71.4
Nevada, Colorado, and Territories	65.0	70.2	65.5	63.3	67.0	59.5	68.5	70.0

Turning from distribution to date, we find 970,000,000 bushels reported in the hands of farmers, or 183,000,000 bushels more than last March, and 462,000,000 bushels more than in 1888. In the Middle States there is no increase over last year. In the Southern States the aggregate is greater by several millions than ever before. The table is as follows:

Sections.	1887.		1888.		1889.		1890.	
	Bushels.	*Per ct.*	*Bushels.*	*Per ct.*	*Bushels.*	*Per ct.*	*Bushels.*	*Per ct.*
New England	3,208,260	36.7	3,177,620	34.6	2,304,580	33.5	2,873,780	33.6
Middle	29,045,170	38.2	28,595,170	34.4	31,759,040	38.0	30,603,350	40.1
Southern	158,354,600	41.9	187,825,040	44.5	182,670,430	44.3	199,408,040	46.5
Western	405,409,820	34.4	278,119,160	30.4	562,563,360	38.6	730,448,050	46.3
Pacific	1,310,640	29.5	1,061,960	21.7	1,112,310	24.9	1,321,250	28.6
Nevada, Colorado, and Territories	6,016,220	33.0	9,494,560	40.5	6,672,340	31.5	5,284,010	30.0
Total	603,344,650	36.2	508,273,510	34.9	787,482,060	39.6	969,93[illegible],480	45.9

There are twelve States in the Western group, but only seven of them may be considered sources of the commercial supply. It is more important to consider the corn surplus States relative to the question of distribution. The following statement shows the proportion of the crop on hand in these States:

States.	1887.		1888.		1889.		1890.	
	Bushels.	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*
Ohio	33,671,400	35	22,139,100	30	38,137,380	41	37,360,260	42
Indiana	43,954,150	37	19,992,000	28	50,191,200	40	47,995,200	45
Illinois	77,632,660	37	43,734,800	31	114,004,600	41	124,380,000	48
Iowa	59,654,100	30	62,390,680	34	114,075,120	41	167,983,680	48
Missouri	43,112,700	30	39,465,720	28	72,929,880	36	102,855,270	47
Kansas	40,547,840	32	18,371,280	24	52,201,380	33	117,848,920	49
Nebraska	45,635,470	43	34,465,500	37	57,686,800	40	68,789,780	46
Total	344,208,320	34.4	240,559,080	30.8	499,226,360	39.0	667,213,110	47.2

In these States the stock on hand appears to be 667,000,000 bushels, or 69 per cent. of the aggregate for the country, and about the average aggregate for the entire crop at this date for the past eight years. It is seen, also, as a noticeable but by no means a surprising fact, that about seven-tenths of this surplus is in States beyond the Mississippi, and that nearly half of the corn remaining in the country is in these

States: Iowa, Missouri, Kansas, and Nebraska. It reduces to narrow limits the commercial search for supplies of corn.

The present crop was well ripened and of good quality, with a high percentage of merchantable grain. The crop of 1883 was somewhat better, and that of 1885 quite as good. The difference in the quality of the crops of seven years past is thus indicated by the record:

Years.	Merchantable.		Unmerchantable.	
	Bushels.	*Per ct.*	*Bushels.*	*Per ct.*
1883	935,926,541	60.0	615,140,354	40.0
1884	1,593,332,101	89.0	202,196,331	11.0
1885	1,583,012,860	78.0	353,163,140	22.0
1886	1,438,446,830	86.0	226,994,170	14.0
1887	1,222,166,360	84.0	233,994,640	16.0
1888	1,637,405,930	82.4	350,384,070	17.6
1889	1,810,557,850	85.7	302,334,150	14.3

The value of the crop on the basis of March prices of merchantable and unmerchantable corn, separately estimated, is as follows:

Merchantable, at 27.9 cents per bushel	$504,874,664
Unmerchantable, at 19.2 cents per bushel	58,077,688
Total value, on basis of March prices	562,952,352
Total value, on basis of December prices	597,918,829
Reduction in three months	34,966,477

This is a decline of nearly 6 per cent., which is the natural result of a large surplus with limited demand and high cost of transportation to market. The previous crop was a large one, and a similar fall in prices occured last winter.

States.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Kentucky	30	32	40	37	38	70	52	42	43	35	34	53	34	34
Ohio	38	40	33	39	41	61	62	47	41	32	35	48	35	31
Michigan	52	39	38	45	46	63	59	52	40	34	38	48	42	37
Indiana	34	34	27	34	40	60	48	41	34	29	32	45	31	27
Illinois	31	29	25	31	36	58	47	40	31	28	31	41	29	24
Wisconsin	41	33	29	39	39	54	53	48	34	34	37	42	36	29
Minnesota	40	38	29	27	36	53	45	43	33	32	34	37	32	27
Iowa	25	25	16	24	26	44	38	32	23	24	30	35	24	19
Missouri	28	27	26	25	36	65	39	35	26	25	31	37	30	23
Kansas	24	21	19	27	29	58	37	26	22	24	27	37	26	18
Nebraska	27	18	16	21	25	39	33	24	18	19	20	30	22	17
Dakota	......	......	......	......	......	......	51	45	30	28	37	35	33	33
United States	37	35.8	31.8	37.5	39.6	63.6	48.4	42.4	35.7	32.8	36.6	44.4	34.1	28.3

The export prices of recent years, which follow, can be compared with these farm values by reference to the following table:

Years ended June 30—	Price.	Years ended June 30—	Price.	Years ended June 30—	Price.
	Cents.		*Cents.*		*Cents.*
1878	56.2	1882	66.8	1886	49.8
1879	47.1	1883	68.4	1887	48.0
1880	54.3	1884	61.1	1888	55.0
1881	55.2	1885	54.0	1889	47.4

WHEAT.

The proportion of the crop remaining in the hands of growers on the 1st of March usually ranges from 26 to 33 per cent. In 1885 it was 33 per cent. The present returns make it 31.9 per cent. of the crop of 1889, or 156,000,000 bushels. The lowest percentage ever reported was within a fraction of 26 per cent. after the disastrous season of 1881. The statement for ten years is as follows:

Year.	Crops of previous years.	In farmers' hands March 1.	
	Bushels.	*Bushels.*	*Per ct.*
1890	490,560,000	156,000,000	31.9
1889	415,8[illegible]8,000	112,000,000	26.9
1888	456,329,000	132,000,000	28.9
1887	457,218,000	122,000,000	26.7
1886	357,112,000	107,000,000	30.1
1885	512,765,000	169,000,000	33.0
1884	421,086,160	119,000,000	28.3
1883	504,185,470	143,000,000	28.4
1882	383,280,090	98,000,000	25.6
1881	498,549,868	145,000,000	29.1

The wheat crop of 1889 was exceeded by the crops of 1880, 1882, and 1884. The average remainder in the hands of growers on the 1st day of March, for ten years past, has been 130,000,000 bushels; the average crop during this period 450,000,000 bushels. Only in years having a product much below this average has the March remainder fallen below 130,000,000 bushels, with the sole exception of 1886, when a crop of 457,000,000 followed one of 357,000,000.

The distribution of the crop is thus presented:

	Distribution.	Supply.
	Bushels.	*Bushels.*
Visible supply March 1, 1889		32,000,000
In farmers' hands March 1, 1889		112,000,000
Crop of 1889 (round numbers)		490,000,000
Consumption, twelve months	298,000,000	
Seed, spring and fall	54,000,000	
Exported March 1, 1889, to March 1, 1890	98,000,000	
Visible supply March 1, 1890	29,000,000	
In farmers' hands March 1, 1890	156,000,000	
Total	635,000,000	634,000,000

Average farm price of wheat for the years 1875–'89.

States.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
Kentucky	$1.05	$1.00	$0.99	$0.76	$1.08	$0.93	$1.31	$0.90
Ohio	1.09	1.14	1.24	.86	1.20	1.02	1.29	.95
Michigan	1.15	1.16	1.22	.85	1.17	.97	1.25	.90
Indiana	.97	1.02	1.13	.81	1.17	.99	1.27	.90
Illinois	.91	.93	1.04	.75	1.07	.95	1.22	.86
Wisconsin	.91	1.01	.93	.67	1.04	1.00	1.19	.90
Minnesota	.86	.90	.91	.51	.94	.87	1.06	.82
Iowa	.71	.90	.87	.50	.92	.82	1.06	.70
Missouri	.95	.89	1.00	.67	1.01	.89	1.19	.85
Kansas	.87	.86	.82	.59	.89	.70	1.05	.67
Nebraska	.64	.73	.83	.49	.84	.73	.97	.67
Dakota								.80
United States	1.00	1.037	1.082	.777	1.108	.951	1.193	.882

Average farm price of wheat for the years 1875–'89.

States.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
Kentucky	$0.95	$0.74	$0.95	$0.72	$0.73	$0.96	$0.72
Ohio	.99	.75	.91	.74	.75	.97	.76
Michigan	.96	.74	.84	.73	.74	.98	.74
Indiana	.95	.67	.86	.70	.72	.94	.71
Illinois	.92	.63	.81	.69	.70	.93	.70
Wisconsin	.88	.60	.76	.68	.64	.96	.70
Minnesota	.80	.50	.70	.61	.59	.92	.71
Iowa	.80	.55	.67	.60	.61	.85	.63
Missouri	.88	.62	.77	.63	.62	.88	.64
Kansas	.78	.45	.65	.58	.61	.88	.55
Nebraska	.70	.42	.57	.47	.53	.83	.52
Dakota	.72	.46	.63	.52	.52	.91	.60
United States	.91	.645	.771	.687	.681	.926	.698

Average export price of wheat.

Years.	Average price.	Years.	Average price.
1874–'75	$1.12	1882–'83	$1.13
1875–'76	1.24	1883–'84	1.07
1876–'77	1.17	1884–'85	.862
1877–'78	1.34	1885–'86	.870
1878–'79	1.07	1886–'87	.890
1879–'80	1.24	1887–'88	.853
1880–'81	1.11	1888–'89	.897
1881–'82	1.19		

The weight per bushel is determined by an investigation which includes the returns of Department correspondents, State agents and their correspondents, and prominent millers. The aim is to give as nearly as possible the average of all grades of wheat. It is evident that in many estimates which reach us from foreign countries only merchantable wheat is included, sometimes high-grade wheat, so that the figure, if taken as an average of the entire crop, is too high. It is not difficult to find wheat in this country that weighs 60 to 65 pounds per Winchester bushel, which is a little smaller than the imperial English bushel. This is simply justice to the grain of the United States, which might otherwise sustain undeserved prejudice. The weight of the last seven crops, as thus estimated, is as follows:

Years.	Weight per bushel.	Measured bushels.	Weight in pounds.	Bushels of 60 pounds.
1883	56.9	420,154,500	23,906,128,850	398,435,481
1884	58.3	512,763,900	29,912,751,800	498,545,863
1885	57.0	357,112,000	20,369,787,000	339,496,449
1886	58.4	457,218,000	26,686,632,000	444,777,202
1887	58.5	456,329,000	26,702,852,300	445,047,538
1888	56.5	415,868,000	23,485,066,800	391,417,782
1889	57.7	490,560,000	28,287,039,600	471,460,663

The average weight per measured bushel of the seven crops is 57.7 pounds. The last crop is, therefore, exactly the average of the seven. In bushels of 60 pounds it makes 471,460,663 bushels; less by 27,000,000 commercial bushels than the crop of 1884.

THE ARID LANDS.

The distribution of crops, methods of culture, and management of farm animals in the arid region are so at variance and in contrast with conditions obtaining in the districts of adequate rain-fall that our ordinary statistical methods are only partially applicable to the territory west of Kansas and Nebraska. Crops have been so scattered that no accurate generalizations upon area or condition could be hazarded, and breadths so small that 100 per cent. increase in a single year might not be improbable. The status of individual crops has been liable to extraordinary and sudden changes. As to farm animals, the owners themselves do not know the numbers of the range stock, and can obtain only an approximation of the facts once a year at the round-ups, and some of them do not care to impart the indefinite knowledge they possess. The assessor's returns, as a rule, are lamentably incomplete, and are supplemented, in the estimates of all intelligent people, by 50 to 100 per cent. increase, according to the proportion of omissions which local tests, the beef outcome, and other evidences tend to prove. The United States census itself is and can be only an approximation, though it should be made a close one by thorough revision and test of returns and estimates.

Years ago it was seen that more minute and searching methods of collecting statistics than those available in settled parts of the country would be necessary, involving something more than voluntary work and requiring special appropriation, at least while the allotment for collection of statistics is so small as at present.

At the last session of Congress a small part of the regular appropriation for statistics was reserved, by a proviso, "for special investigation of the agricultural statistics of the Rocky Mountain region." An investigation has been commenced and will be continued, with the very limited means available for such purpose, to obtain a more complete and accurate view of the agricultural resources of that part of the continent and of the extent and direction of their development. A statistical survey of the mountain region is now of vast importance as an indication of the real value of its natural resources and as a stimulus to their development.

The recent brief journey of the Statistician, which occupied scarcely a month, sufficed for a hasty observation of portions of western Nebraska, Colorado, and Wyoming, a conference with civil and agricultural officials and representatives of rural industries and irrigation enterprises, a collection of available facts from State and Territorial archives, and for obtaining a better stand-point of observation of the real condition, tendencies, and limitations of mountain agriculture, and a suitable preparation for planning and pushing the statistical campaign during the current fiscal year.

TRANSITION.

The desert of a few years ago, so bare and barren, and so hopeless in the view of all beholders, estimated only at the value of its carrying capacity for range cattle and sheep, is rapidly changing in appearance and in public appreciation. Its eastern portion, as a newly-found "rain belt," has been carved into homesteads, and farmed without regard to irrigation. It was held alike by sage and citizen, twenty years ago, that half of Nebraska was agricultural, the other

half pastoral; that successful agriculture could not be expected to succeed beyond the 100th meridian. The settler gradually moved westward, and, utterly regardless of this dictum, passed the desert line, building his cabin and turning the soil and growing corn, stopping not even at the Colorado line; and to-day he is growing a better crop of maize in all the eastern counties of the Centennial State than is the farmer of Michigan or northern New York. He has been told that a year of drought and starvation would come, and some pinching droughts have confronted him, as they have the farmer of Illinois; still he has pushed westward with heroic determination, breaking and subduing the soil, and showing by his improvements that he is there to stay.

In a visit to Yuma, Colorado, farmers were found who had fled from the droughts of Illinois, some old men of sixty, starting anew on a desert homestead, who had broken the soil deeply with horses and cattle, and even cows, and are getting wheat yielding twenty bushels per acre, cribbing hundreds of bushels of corn, growing oats and potatoes, hay and vegetables, and converting a former scene of desolation into one of beauty and bloom. Deep breaking, subsoiling, and frequent cultivation, processes the very reverse of those practiced by the pioneer farmer, are the sources of the new prosperity.

Colorado agriculture is contesting with mining for superiority in value of production, and her wisest publicists assert that one-third will this year be produced without irrigation. The eastern counties, the great divide between the Platte and the Arkansas that extends eastward from the base of the mountains, and other areas where potatoes and other vegetables, alfalfa or millets, will grow without irrigation, and the range with its natural pasturage, will give this year of the fruits of the earth many millions of dollars in value by virtue of the rain-fall properly utilized.

What is the cause of this magical change? As the mines in which the ores have been hidden for ages were discovered, so a new agricultural country, that has also existed for ages, has been discovered by the light of practical experience and a higher science. Has there been an increase of rain-fall? The records of the rain-gauge do not show it very conclusively, though it is now said that this instrument is no true test of the real precipitation. Yet there is a change of climate. The agricultural values of the climate have increased. The moisture that was before carried away, flowing from the surface like water from a duck's back, is held in the soil, taken up by the roots of plants, given out through their leaves, or evaporated from the surface of the soil, and a marked increase of humidity of the atmosphere is the result, which is shown in dews unknown before. This humidity is a factor in plant growth, though it is not made apparent by such a measure of precipitation as the rain-gauge.

Thus the homestead area, supposed to be limited to 200 miles west of the Missouri, already extends about 400 miles. The error arose from a deficient knowledge of agricultural meteorology, a misconception of the quality of the arid soil, an underestimate of the actual rain-fall, and a failure in adaptation of rural methods and processes to the unusual conditions prevailing. Nor is the lesson yet fully learned; there are surprises of success in reserve for the experimental arid-lands farmer of the future.

There is another transition in progress. It is partially the effect of this above indicated. These two hundred miles of homesteads

were formerly ranges for cattle and sheep. The great flocks have been driven back to the higher plains or the mountain parks and valleys. As the prosperity of the ranch became known in the East and in Europe, inflation set in, prices advanced, and young cattle were quoted and bought and sold at higher rates than in any other markets of the United States. Millions were invested in ranch property and privileges. The sellers, infatuated as were the buyers, established new ranches, crowded the range, injuring the pasturage and enfeebling the stock. Then came the hard winter of 1886-'87, and fearful losses occurred, which added to the depression caused by declining prices, and deepened the despondency of the cattle grower, who begins to feel that his business must in the future be conducted less on the nomadic idea and in better accordance with economic principles. The stock must be kept in hand, looked after, fed in winter storms when grass can not be obtained, and water must be provided, for it is understood that cattle die of unquenched thirst, when streams are frozen over, as well as from starvation when the grass is covered by snow and ice.

It was a wise and patriotic idea to utilize the grasses of the plains and mountains that were wasted thirty years ago. It was a loss of national income nearly as large as would be the loss of the cotton crop. It was public property, common wealth, and the profits stimulated utilization, till the very cheapness of pasturage threatened its destruction—a forcible illustration of the wastefulness of communism.

The business of ranching has tested its capacity to found a State. It has not endowed with great wealth a populous community, established churches, built school-houses, and dotted with homes of comfort and abundance the landscape. Nor can it. It has done something, if not its best; it has at some points overdone, if it has not done its worst. It is a useful industry yet, to supplement all others that are practicable, on lands that can be irrigated extensively; but there are metals, the useful as well as the precious, to be mined and manufactured, requiring transportation to all points, labor rude and skilled, and all the appliances of art and industry, aided by science and inventive genius. These points gained, agriculture, which has now no motive or opportunity, will flourish and be extended, and a better style of ranching will utilize the areas that would otherwise ever be waste.

The patriotic citizen, looking to the prosperity of the future, does not regret the decadence of the old idea of ranching. Twenty-five acres of pasture used four years in fitting one bullock for the shambles is no basis for the wealth of a State. Population can not be sustained or civilization advanced on this idea. It was a good enough theory for a few pioneers who sought wealth to spend elsewhere, but like cotton in the South, utterly incapable of sustaining a population of millions, whose income from this source would be less than $20 per head. America can give no permanent adhesion to the Arab or any other nomad. Even the cattle grower of the Pampas is tending toward agriculture, and progress is apparent in semi-civilized countries. The Rocky Mountains are resonant with the echoes of progress.

There are further transitions. The cattle no longer wear the Texan character prominently, nor even that of the gaunt and ungainly native of degenerated European blood, but are becoming modified by the Shorthorn, the Hereford, and Polled Angus. This is one reason

for the increase of beef. Animals are heavier, and the quality of the meat is improved. A similar improvement is going on in herds of horses by the impress of the Clydesdale and the Percheron. This improvement leads to another of necessity; better care and feed. All of these tend to improvements which are of the farm rather than of the ranch.

A notable example of this tendency is seen in the course of the Warren Live Stock Company. It is the consolidation of a score or more of small ranches established originally by Governor F. E. Warren and others, at points where water could conveniently be obtained on Bear, Horse, and Pole Creeks, west of Cheyenne. Where water was scarce on the surface, wells sunk in creek beds, and operated by windmills, sufficed for all requirements. The company holds 95,000 acres in fee-simple, 23,000 acres of school and university land, besides a large area in range rights. The location is on the Union. Pacific belt.

The land is improved by the construction of 30 miles of main ditch and 65 miles of laterals, with storage basins of large capacity, by which a large area of meadow land can be flooded at will. A four-wire and top pole fence incloses the whole tract of more than a quarter of million acres, and a telephone system, which uses fourteen instruments, connects the ranches with the Cheyenne office and with each other.

There are kept by this company about 90,000 sheep, 2,500 cattle, 2,000 horses, and 2,500 Angora goats. When others were giving up sheep, under the pressure of low prices, thousands were bought at low rates. Cotswold sires were obtained, and afterwards Shropshires, with the purpose of producing mutton and wool, rather than wool alone. This required better feed, which led to enlargement of irrigated meadows and large increase of hay harvested. But this was not sufficient. A feeding station of 40 acres was obtained in Nebraska, where corn is very cheap, for finishing near the markets the fattening muttons. Here are equipments of shedding, yards, canals, windmills, tanks, troughs, barracks, and other appliances for handling economically 22,000 head of sheep in close proximity to the railroad track. Cattle are also fed here.

This is a practical union of the ranch and farm ideas and an adaptation of methods to changing circumstances, which is the key to the success of all modern enterprises.

The rapid increase of railway facilities is an active agency in the transformations and development which are everywhere apparent. Railroad extension in Colorado has gridironed the State with lines of iron and steel, as is well known. In Wyoming a similar result is imminent, as indicated by the following letter written by the Statistician from that Territory:

Two years ago there were 624 miles of railway lines in the Territory. At the beginning of the present year the mileage has increased to 949. Railroad projectors, with the prophetic vision of their class, see clearly the future development of Wyoming. It is a strikingly significant indication of the wealth which labor, with the aid of soil and sunlight and water, will evolve from the surface and the depths beneath, that four transcontinental railway lines will traverse its territory from east to west. The Union Pacific connects Omaha with Ogden, in Utah, by way of Cheyenne; the Chicago and Northwestern has reached Caspar, almost in the center of the Territory, 153 miles from its eastern border, on its way to Ogden and the Pacific coast; the Chicago, Burlington and Quincy, already near the eastern border, will strike the Platte a little lower, and traverse the oil belt to Utah and a possible Pacific terminus; and, fourth (perhaps not last), the Pacific Short Line is pushing with great rapidity from Sioux City through Nebraska to Wyoming and Utah and the

Pacific coast. These lines are not to subsist upon through business, but will be eventually supported by local traffic, will stimulate settlement, initiate new industries, and furnish cheap transportation to surplus products of lands made productive by irrigation. The Cheyenne Northern, a branch of the Union Pacific, is pushing its way to the Northern Pacific, and the Wyoming Southern promises a line from Montana via Sheridan and Buffalo to Caspar. Already oats and wheat are a "drug" in the market of Johnson County for want of a railway outlet, selling at Nebraska prices to the few who have occasion to purchase. Southern Wyoming has formerly been hampered and restricted in its development by the unfortunate policy of the Union Pacific, which has stimulated through traffic to the neglect and discouragement of local development. The present management is working on a wiser plan, and competition will enforce its perpetuation. Cheyenne is the very center of its system and the location of its new repair shops, where 1,000 workmen will help to ncrease the population and prestige of the Territory.

IRRIGATION PROBLEMS.

After all that can be done in dry farming, irrigation is a necessity. The land is almost everywhere fertile, generally to excess, lacking only water to insure large and certain production. This source of production can be more fully utilized, greatly enlarging the domain of agriculture, though it can not render productive the entire area. In Colorado some are inclined to claim adequate water supply for one-fifth of the surface; while others, including local engineers of experience, think that not more than a tenth can be irrigated. The different stages of progress in water utilization are six in number:

(1) The use of the rain-fall in what are properly known as rain belts, by the most effective methods of cultivation, and the selection of suitable plants, especially those with long tap roots.

(2) The exhaustion of the supply furnished by rivers and creeks in their passage through the plains, by means of irrigation works, such as are already in so extensive use.

(3) The enlargement of the current supply, by the storage at higher elevations of water which passes away in spring floods, as is proposed now by the Government.

(4) The sinking of galleries below the surface of streams, even when they are practically dry, and utilizing by canals the underground currents. This is becoming a common and popular resource. Such a plan furnishes pure filtered water, at Cheyenne, for the supply of the city, without pumping or much expense, from Crow Creek, a small stream, nearly dry in summer.

(5) By the use of irrigating pumps of great power in lifting such underground currents to the surface from bed-rock, for application to lands surrounding.

(6) By artesian wells, which have hitherto proved too expensive for use in irrigation. It is possible that their cost and the uncertainty of obtaining water will prevent extensive employment of this means of water supply, though they are quite successful in Dakota.

The building of numerous catch-basins throughout the plains to save the rain-fall which is wasted, so far as the lands near by are concerned, will add greatly to the supply furnished by the second expedient indicated. There are natural depressions everywhere which can be utilized at very slight cost and with entire immunity from risks of dangerous floods.

The utilization of surface water does not exhaust the supply for irrigation. The application involves waste. The fugitive waters, as if by an instinct of preservation from threatened dissolution under the fierce rays of the unobscured sun, sink through the sands, pass

into the depressions which make the water-ways, and gradually swell the scanty streams at lower levels or course their way towards the sea through the sands below the river beds. Thus a part of the water of irrigating canals is gathered a second time to do the work of irrigation. This is the case notably in the South Platte, after its waters have been depleted by the canals about Denver, and the Cache la Poudre supply has been similarly used between Fort Collins and Greeley. At the latter place the cellars require protection from overflow, water in wells has risen near to the surface, and the waters of irrigation are partially restored to the stream to find their way to the South Platte.

Fort Morgan is on the plains at the bend of this river, about 80 miles below Denver. Six years ago there was a desert of scanty and brown grass and cactus plants, where now, by the aid of irrigation enterprises, are flourishing and productive farms, tens of thousands of acres of lands already reclaimed, with a prospect of obtaining water for nearly two hundred thousand in the near future. It is claimed that there is already expended nearly $750,000, mostly by citizens of the county, and lands with water are offered near town for $10 to $15 per acre.

In Wyoming a development company has expended $450,000 in tunneling the Laramie and preparing to irrigate a tract of about 60,000 acres, most of which has been bought of the Government and paid for, and is now awaiting settlement. This praiseworthy effort to demonstrate the possibilities of agriculture in Wyoming, and to provide a vegetable and small-fruit supply for Cheyenne, has been expensive to its originators, through unexpected delay in obtaining title, yet magnificent farms, it is expected, will soon be offered to settlers at less than cost of water for their irrigation.

The productiveness of these irrigated lands is surprising. Facts abound, for which there is no present space, attesting lavish yields. Hay is the principal crop. Alfalfa and potatoes produce heavily and occupy large areas. Oats are abundant. Wheat is limited by the demand. Statistics of production will appear in the future at proper time and place.

TRANSPORTATION RATES.

The section of freight rates which was organized by a requirement of Congress July 1, 1882, has presented in each monthly crop report of this division during the year statements showing through and local rates of freight upon the principal products of agriculture and farmers' supplies from important points of shipment in all parts of the country to large market centers, by rail and water; also the cost of transporting our surplus agricultural products to foreign countries. The rates shown were those in operation upon the first day of each month, and did not show the fluctuations occurring between the reports.

The returns from the several trunk lines, Chicago to New York and points taking New York rates, were characterized by their uniformity and sameness throughout the year. The rates reported upon many of the products were the same each month. Live sheep and hogs and lard and pork were reported at 30 cents per 100 pounds in car-load lots each month during the year. Grain and flour 25 cents. The rate on cattle was reported January, February, March, and April 1 at 22½ cents per 100 pounds and 26 cents for the balance of

the year. Dressed beef was shipped at 50 cents until June 1, when the rate dropped to 45 cents and continued the same the remainder of the season.

For a comparison of the rates upon some of the more important articles of shipment, reported upon the first day of each month for a series of years, the following statement is presented:

Months.	Cattle, car-load.					Sheep, car-load.					Hogs, car-load.				
	1885.	1886.	1887.	1888.	1889.	1885.	1886.	1887.	1888.	1889.	1885.	1886.	1887.	1888.	1889.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Jan. 1	40	25	35	35	22½	50	25	45	40	30	30	30	35	30	30
Feb. 1	40	25	35	35	22½	50	25	45	40	30	30	30	35	30	30
Mar. 1	40	35	35	35	22½	50	45	45	40	30	30	30	35	30	30
Apr. 1	40	35	35	35	22½	50	45	45	40	30	25	30	35	30	30
May 1	40	35	35	35	26	50	45	40	40	30	25	30	35	30	30
June 1	30	35	35	25	26	40	45	40	25	30	25	30	35	30	30
July 1	25	35	35	16½	26	40	45	40	25	30	20	30	30	30	30
Aug. 1	25	35	35	5½	26	40	45	40	25	30	25	30	30	18	30
Sept. 1	25	35	35	10	26	40	45	40	25	30	25	30	30	18	30
Oct. 1	25	35	35	15	26	40	45	40	25	30	25	30	30	18	30
Nov. 1	25	35	35	15	26	40	45	40	25	30	25	30	30	20	30
Dec. 1	25	35	16½	15	26	40	45	19	25	30	30	30	30	25	30

Months.	Grain and flour, car-load.*					Lard and pork, car-load.					Dressed beef, car-load.				
	1885.	1886.	1887.	1888.	1889.	1885.	1886.	1887.	1888.	1889.	1885.	1886.	1887.	1888.	1889.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Jan. 1	25	25	30	27½	25	30	30	35	33	30	70	43½	65	65	50
Feb. 1	25	25	30	27½	25	30	30	35	33	30	70	43½	65	65	50
Mar. 1	25	25	30	27½	25	30	30	35	33	30	70	65	65	65	50
Apr. 1	20	25	30	25	25	25	30	35	20	30	70	65	65	65	50
May 1	20	25	25	25	25	25	30	30	30	30	70	65	65	65	50
June 1	20	25	25	25	25	25	30	30	30	30	70	65	65	65	45
July 1	15	25	25	25	25	25	30	30	30	30	43½	65	65	26½–40	45
Aug. 1	20	25	25	25	25	25	30	30	18	30	43½	65	65	7	45
Sept. 1	20	25	25	25	25	25	30	30	18	30	43½	65	65	25	45
Oct. 1	20	25	25	20	25	25	30	30	18	30	43½	65	65	35	45
Nov. 1	20	25	25	20	25	25	30	30	30	30	43½	65	65	35	45
Dec. 1	25	25	25	20	25	30	30	30	25	30	43½	65	31	35	45

* Not including unground corn after August 1. From August 1 to December 1 the rate on corn was 20 cents per 100 pounds.

REDUCTION IN FREIGHT RATES.

There has been a very heavy reduction in the rates of freight upon all classes of agricultural products during the past twenty years. Especially is this true of the rates from large accumulating points in the West to the sea-board, whether intended for home consumption or export.

The construction of new competing lines, better facilities for transporting and quicker handling of large shipments, and the competition for business at those points of shipment where several roads terminate, as well as the action of the law of supply and demand, and the convenience of carrier or shipper, are some of the principal causes of the decrease.

The following statement shows the average rates on corn and wheat from Chicago to New York and the per cent. of decrease from 1870 to 1889, inclusive, and from St. Louis to New York on grain from 1876:

[Average rate in cents via all rail.]

Years.	Chicago to New York.				St. Louis to New York.	
	Corn per bushel.		Wheat per bushel.		Grain per 100 pounds.	
	Average rate.	Per cent. of decrease.	Average rate.	Per cent. of decrease.	Average rate.	Per cent. of decrease.
1870	28.	....	30.00	....	....	....
1871	29.63	*6.0	31.80	*6.0	....	....
1872	32.66	*16.6	34.99	*16.6	....	....
1873	28.93	*3.3	31.02	*3.4	....	....
1874	24.50	12.5	26.25	12.5	....	....
1875	22.40	20.0	24.00	20.0	....	....
1876	15.74	43.8	16.86	43.8	39½	....
1877	18.90	32.5	20.50	31.7	41	*3.8
1878	16.52	41.0	17.70	41.0	38	3.8
1879	14.56	48.0	17.74	40.9	33½	15.2
1880	17.48	37.6	19.80	34.0	42	*6.3
1881	13.40	52.1	14.40	52.0	32	19.0
1882	13.50	51.8	14.47	51.8	29½	25.3
1883	15.12	46.0	16.20	46.0	33	16.5
1884	12.32	56.0	13.20	56.0	26	34.2
1885	12.32	56.0	13.20	56.0	22½	43.9
1886	14.00	50.0	15.00	50.0	29	26.6
1887	14.70	47.5	15.75	47.5	32 2/15	18.7
1888	13.54	51.6	14.50	51.7	29½	25.3
1889	12.82	54.2	15.00	50.0	†28½	27.8

* Increase.

† Corn 26 cents.

Statement showing the weekly range of rates of freight upon corn and wheat, Chicago to New York, via the three great routes for the years 1887, 1888, *and* 1889.

[In cents per bushel.]

Week ending—		Lake, Chicago to Buffalo.						Erie Canal, Buffalo to New York.						Chicago to New York, lake and canal.					
		1887.		1888.		1889.		1887.		1888.		1889.		1887.		1888.		1889.	
		Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.
May	10	3¼	3	2	1¾	2¼	2	6¼	5¾	5	.....	4	3⅝	9½	8⅜	7	.....	6¼	5⅜
	17	3¼	3	2	1¾	2¼	2	5	4⅗	3	2¼	4	3⅝	8¼	7⅝	5	4½	6¼	5⅝
	24	3½	3¼	2¼	2	2	1¾	4½	4⅛	2⅞	2⅝	4	3⅝	8	7⅜	5⅛	4⅝	6	5⅝
	31	3¾	3½	2¼	2	2¼	2	4¼	4	3¼	3	4	3⅝	8	7½	5½	5	6¼	5⅝
June	7	4¼	4	.....	2	2¼	2	4½	3⅞	3¾	3½	4	3⅝	8⅝	7⅗	.....	5½	6¼	5⅝
	15	5	4	2	1½	2¼	2	4¾	4¼	2¾	2½	3¾	3¾	9¾	8¼	4¾	4	6	5⅝
	22	6	5½	1¾	1½	2	1¾	5	4½	2⅛	1⅞	3¾	3⅗	11	10	3⅞	3⅜	5¾	5⅛
	30	5¼	4¾	2¼	2	2	1¾	4	3½	2⅛	2	3¾	3⅝	9¼	8¼	4⅗	4	5¾	5⅛
July	7	4¼	4	2¼	2	2	1¾	4	3⅝	2¼	2	3¾	3⅗	8¼	7⅞	4½	4	5¾	5⅛
	14	4	3¾	1¾	1½	2¼	2	4	3⅗	2½	2¼	3¾	3⅗	8	7⅜	4¼	3¾	6	5⅝
	22	3½	3¼	.....	2	2¼	2	3¾	3⅗	2¾	2½	3¾	3⅝	7¼	6⅝	.....	4½	6	5⅝
	29	3	2¾	.....	2¼	2	1¾	3¾	3⅝	2⅗	2⅜	4	3⅗	6¾	6⅕	.....	4⅝	6	5⅝
Aug.	7	3½	3	2¾	2½	2¼	2	4	3⅝	3½	3¼	4	3⅝	7¼	6⅝	6¼	5¾	6¼	5⅝
	15	3¼	3	3	2¾	2½	2¼	3⅞	3½	4¼	4	4	3⅝	7⅕	6½	7¼	6¾	6⅓	5⅞
	23	3⅗	3⅝	3¼	3	2¾	2½	3⅞	3½	4⅜	3⅞	4	3⅝	7¾	7⅓	7⅗	6⅕	6⅞	6⅛
	30	4½	4	3¼	3	3	2¾	3¾	3½	4⅛	3¾	4½	4	8¼	7½	7⅖	6⅜	7½	6¼
Sept.	7	4⅝	4	3½	3¼	2⅞	2⅝	4	3⅝	3⅞	3½	4½	4	8⅜	7⅝	7⅜	6⅜	7⅜	6⅝
	15	4	3¾	3¾	3½	2⅞	2⅝	3¾	3⅛	3½	3¼	5	4½	7¾	7¼	7¼	6¾	7⅘	7⅓
	22	4	3¾	3¾	3⅕	2⅞	2⅝	4	3¾	4	3⅗	5	4½	8	7½	7⅖	7⅛	7⅘	7⅓
	29	4	3¾	3¼	3	3	2¾	4	3¾	3¾	3½	5	4½	8	7½	7	6½	8	7¼
Oct.	7	4	3¾	3	2½	3	2¾	4¼	4	3¾	3¼	5	4½	8¼	7¾	6¾	5¾	8	7¼
	14	4½	4	2½	2¼	3	2¾	4¼	4	3¾	3⅜	5	4½	8½	8	6¼	5⅝	8	7¼
	22	5½	5	2¼	2	3	2¾	5	4½	3¾	3¼	5	4½	10⅛	9½	6	5¼	8	7¼
	29	5½	5	2¼	2	3⅛	2⅞	4¾	4⅝	4	3⅗	5	4½	10½	9⅝	6¼	5⅝	8⅛	7⅝
Nov.	7	4¾	4½	2¾	2½	3	2½	4¾	4½	4⅛	3½	5	4½	9½	9	6⅞	5⅞	8	7
	15	2¾	2	2¼	2	2	1¾	5½	5	2¾	2½	5	4⅝	8¼	7	5	4½	7	6⅛
	22	.....	3	2	1¾	2½	2¼	6¾	6	4¼	3½	5	4⅝	.....	9	6¼	5¼	7½	6⅝
	30	.....	4½	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Average cost per bushel for transporting wheat from New York to Liverpool, from 1866 to 1889, inclusive.

[Price reduced to cents at 2 cents per penny.]

Years.	Steamer rates.		Years.	Steamer rates.	
	Pence.	*Cents.*		*Pence.*	*Cents.*
1866	4.74	9.48	1878	7.61	15.22
1867	5.18	10.36	1879	6.20	12.40
1868	7.18	14.36	1880	5.88	11.76
1869	6.40	12.98	1881	4.08	8.16
1870	5.78	11.56	1882	3.87	7.74
1871	8.16	16.32	1883	4.54	9.08
1872	7.64	18.28	1884	3.40	6.80
1873	10.56	21.12	1885	3.60	7.20
1874	9.08	18.16	1886	3.46	6.92
1875	8.07	16.14	1887	2.71	5.42
1876	8.02	16.04	1888	2.67	5.34
1877	6.93	13.86	1889	4.06	8.12

Average monthly prices paid for carrying grain from New York to Liverpool for five years.

Months.	1885.		1886.		1887.		1888.		1889.	
	Pence.	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*
January	5.33	10.66	3.37	6.75	4.91	9.83	2.41	4.83	4.16	8.33
February	4.41	8.83	2.33	4.66	3.66	7.33	1.83	3.66	4.33	8.67
March	3.33	6.66	2.41	4.83	3.16	6.33	.83	1.66	3.96	7.92
April	3.83	7.66	3.66	7.33	1.50	3.00	.43	.87	2.91	5.83
May	3.66	7.33	3.79	7.58	1.58	3.16	.62	1.25	2.50	5.00
June	2.75	5.50	4.75	9.50	2.12	4.25	1.66	3.33	3.41	6.83
July	2.41	4.83	2.83	5.66	2.62	5.25	1.75	3.50	3.00	6.00
August	2.33	4.66	1.83	3.66	3.00	6.00	2.33	4.66	4.33	8.67
September	3.16	6.33	2.66	5.33	1.83	3.66	5.33	10.66	4.08	8.17
October	4.00	8.00	4.00	8.00	2.00	4.00	4.50	9.00	5.41	10.83
November	3.50	7.00	4.25	8.50	3.50	7.00	4.50	9.00	5.58	11.17
December	2.66	5.33	4.66	9.33	3.00	6.00	5.87	11.75	5.00	10.00

These tables illustrate the reduction of transportation rates in a clear and striking manner. The average rate on corn, from Chicago to New York, for instance, was 32.66 cents in 1872, and 12.82 in 1889. The wheat rate was 34.99 cents in 1872, and 15 in 1889. The steamer rates gradually increased from 1866 to 1873, then declined until 1882, and have since remained low with some fluctuations, the lowest rates being reported in 1887 and 1888. The decline is from 21.12 cents in 1873 to 5.34 in 1888. The cost is now about three times as much from Chicago to New York as from New York to Liverpool. The cost of carriage is doubtless greater, in many instances, from the farm to Chicago than from Chicago to Europe. So it costs the price of two bushels of corn to get the third from Nebraska fields to the foreign market; and it also costs a large fraction of a bushel of wheat to send a bushel to Liverpool.

The cost of getting corn to Chicago, under the present relatively low rate, is this year so burdensome, in view of the low prices received, as to discourage the grower and keep much of his surplus in the bin.

J. R. DODGE,
Statistician.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE CHIEF OF FORESTRY DIVISION.

SIR: I have the honor herewith to submit my fourth annual report on the work of the Forestry Division.

As I have pointed out in my former reports, neither the facilities nor the present organization of the division are adequate for such work as is required and would be justified by the importance and magnitude of the interests which could be subserved by this division. Conceived simply as a bureau of information, the facilities for obtaining the information under Government methods have hitherto been insufficient; the amounts appropriated, while unnecessarily large for a simple correspondence bureau, have never been large enough to undertake and carry through any extensive and systematic investigations such as are needed, such as can only be carried on under Government control and are worthy of governmental effort.

Hampered by the inability to command and compensate the service of competent co-workers and without sufficient assistance, all efforts to build up in a systematic manner the work of the division, as outlined in my report for 1887, had to be deferred. Whatever of value has been produced in the division must be credited to the personal interest and effort of individual workers beyond any compensation that could be offered to them, and not to superior organization and facilities such as might have been expected.

As I shall show further on, there is no room for doubt as to what kind of work this division should engage upon, as soon as it is properly equipped and endowed with sufficient appropriations. Pending the absence of such provisions, the work can only remain preparatory and crude, unsatisfactory to those who have a conception of the needs of forestry in this country.

The most promising and satisfactory investigation which has been completed during the year has concerned itself with railroad interests in forest supplies, and especially with the prospects of substituting metal ties for wooden ones. The success of this latter investigation, which will result in presenting a complete history of the experiences with metal ties in all countries, is due to the indefatigable industry and devoted attention to the subject of Mr. E. E. Russell Tratman, civil engineer, whose preliminary report, issued during the year in Bulletin 3, will be followed by a full account, with all desirable detail, such as can not be found collected in any other literature or language.

The appreciation which even the preliminary report has received both in this country and abroad will amply justify the attention given to this special line of inquiry.

While one English technical journal has copied the report verbatim, the London "Industries" in reviewing it uses the following language:

> We would hardly look for "light and leading" on this subject from such a source; but it is nevertheless a fact that probably the most comprehensive statement that has hitherto appeared relative to the substitution of metal for timber for railway purposes has emanated from a department that is only interested in the matter in so far as the forests of the United States are concerned.

That this publication has been timely and has done its share in stimulating our railroad engineers to begin experimenting with metal ties on a large scale may be estimated from the frequent calls for copies by railroad managers, which made a second edition of the Bulletin necessary. As will appear in the full report in Bulletin 4, several railroads in this country have since put, experimentally, a larger number of metal ties on their tracks, while the mileage on metal ties in use in foreign countries exceeds 25,000 miles.

A canvass among our railroad managers in regard to supplies, prices, etc., of wooden ties has also been made and the results will be presented in comparison with a similar canvass made by the division seven years ago, thus showing the change of conditions, if any, in the various localities.

The magnitude of this special drain on forest supplies, which it will be remembered amounts to at least 500,000,000 cubic feet of timber—and that of the thriftiest and most valuable—as well as the appreciation which has been shown on the part of the railroad companies in this canvass by furnishing desired information, may justify the prominence given to this interest.

In passing, it may be mentioned that as a result of circulars issued by the Department through this division, the employment for ties of chestnut oak, which formerly had remained unused in the woods after the tanbark had been stripped off, is reported from those localities where the former wasteful practice existed.

A canvass has been instituted into the needs of the cooperage industry, which uses probably not less than 250,000,000 cubic feet of wood bona fide, and a large amount in addition on account of wasteful methods. For the State of Tennessee this canvass has been completed by the special agent appointed for this division from that State, showing a bona fide consumption of 10,000,000 cubic feet of wood for cooperage while, with the few exceptions where it is made into cord-wood, the remainder of the tree is wasted. In by far the larger part of the State where this industry is carried on the supply of material (almost entirely white oak) is reported scarcer by 10 to 50 per cent.

The Carriage Builders' National Association last year had appointed a committee on timber supply. The chairman of the committee, Mr. H. G. Shepard, of New Haven, Conn., requested the co-operation of the division in ascertaining the present condition of supplies for this branch of wood-consuming industries, which is estimated to use annually about 25,000,000 cubic feet of wood of special quality, worth round $10,000,000. To gratify this reasonable demand, Mr. Adolph Leue, secretary of the Ohio Forestry Association, who had given some attention to the wagon and carriage manufacturers' interests, was asked to prepare himself for conducting such a canvass as would yield the desired information; but it was found that the finances of the division would not permit the undertaking of this canvass, and it had to be deferred.

The investigations into the technology of our timbers, and especially into the conditions upon which the qualities of our timbers depend—for which Mr. Roth, of Ann Arbor, had begun preliminary studies—has also made but slow progress for lack of means to supply proper material. As has been pointed out before, to make such investigations of practical utility the material for study must be very carefully collected by competent men, as it is necessary to note the conditions under which the samples have developed, and to make

certain determinations on the spot. Inability to command such competent assistance has put a check to Mr. Roth's work. He has furnished, however, a comparative study of the woods of the three prominent Southern pines—the Long-leaf, Short-leaf, and Loblolly, which will be printed eventually, together with the monographs on the life history of these trees.

These biological studies have been enriched during the year by several monographs on the most important Eastern pines, notably those of Dr. Charles Mohr on the Short-leaf, Loblolly, and Cuban pines. This last valuable pine, as yet but little known and not widely distributed, the observant author considers, for various reasons, as destined to replace the Long-leaf pine in the Southern forest of the future.

The monographs now on hand still unpublished comprise the following species: The White Pine (*Pinus Strobus*), by Prof. S. V. Spalding; the Norway and Pitch Pines (*Pinus resinosa and rigida*), by Prof. William Flint; the Hemlock (*Tsuga Canadensis*), by Prof. A. N. Prentiss; the two Northwestern spruces (*Picea nigra* and *alba*), by Miss Kate Furbish; the Long-leaf, Short-leaf, Loblolly, and Cuban pines (*Pinus palustris, mitis, Tæda* and *Cubensis*), by Dr. Charles Mohr.

The publication of these monographs, which give a complete account of the history and development of these trees, it is hoped will be no longer delayed, as they constitute the most valuable work in the division within the last three years. The illustrations which are to accompany these—woodcuts of the highest order—have been partly finished during the year, and will enhance the value of the publication.

During the first months of the year much time was spent in finishing the collective forestry exhibit for the Paris Exposition, which was accompanied by a report—so far published only in French—giving a bird's-eye view of forests, forest conditions, and forest utilization in the United States.

The exhibit, which attempted in a small compass to give a systematic view of these matters, was recognized by the grant of a gold medal. Another gold medal was bestowed upon the writer for his efforts in forest educational direction, and several of the exhibitors in the section of forestry received prizes. A model of a tree-planting machine, described in my last year's report, was also recognized by a gold medal, and a bronze medal was accorded for a collection of forest-tree seeds.

In this connection it may be of interest to mention that the authorities of the National Museum have seen fit to establish a special branch of forestry collections, which has been placed under the honorary curatorship of the writer. It is a promising sign for the cause of forestry in this country that such recognition has been given to its existence and importance, since the idea of establishing such special collections is original and not copied from any of the other national museums of the world. For the present, therefore, the educational value of this departure will be mainly kept in view in these exhibits.

During the summer the writer furnished an extensive report for the use of the Senate Committee on Irrigation, outlining the relation of forests to irrigation problems. For the better performance of this task, an extended but rapid journey across the regions under consideration was made by the writer, which afforded a bird's-eye

view of the varying conditions prevailing over the treeless plains and wooded plateaus and mountains of the west. A short side trip into the Puget Sound regions, the red woods of California, and into the Sierra Nevada was crowded into the journey, to gain a long-needed personal insight into the forest growths of those regions. Such a hasty journey, covering over 10,000 miles of travel in less than seven weeks, can of course lead to nothing more than impressions and the gathering of a few unconnected notes of interest. Some of these may be pertinent enough to be here briefly stated:

(1) The dryness of the plains east of the Rocky Mountains, as far as it is inimical to vegetation, is due, probably, not so much to the small rain-fall as to the enormous evaporation under the influence of the constant winds, which produce summer droughts as well as winter droughts. At least, the only means for influencing water conditions of a very large part of this region appears to be in checking or reducing this evaporation by the planting of wind-breaks and timber belts.

(2) The area which needs such protecting timber belts is so enormous that it seems almost hopeless to rely upon the effort of pioneer settlers for this work of timber planting, especially as the unsystematic manner in which such private planting must necessarily proceed, in addition to the existing most unfavorable climatic conditions, has led and must lead to failures more frequently than to successes.

(3) A tree will die where a forest would live; that is to say, planting on a large scale and in compact bodies may be successful, where smaller plantations will succumb to the extremes of the climate. Hence the poor settler on the frontier who can not afford to start a large enough plantation, will be doomed to reiterated failure and discouragement with his trees as well as his crops.

(4) The most serviceable trees for wind-breaks and for subsistence in a dry climate—the evergreen conifers—which require from six to ten times less water than most deciduous trees, do not recommend themselves to the use of pioneer planters, because they require much care to establish them in the open sites of the plains and grow only slowly to useful sizes.

(5) All these considerations lead to the conclusion that successful reclamation of these broad acres and effectual checking of the destructive winds by means of systematic planting of forest belts can only be attained by co-operation, *i. e.*, by government management, be it national, State, or county.

(6) The most promising conifers for planting on the plains and prairies, besides the Scotch, Austrian, and Norway Pines and the Juniper or Red Cedar in the lower latitudes, seem to be the two Rocky Mountain conifers, the Bull Pine and the Douglas Spruce.

(7) The condition of the Western mountain forests, upon which largely the water supply for irrigation purposes depends, is most discouraging, and the result of their devastation is already noticeable in the irrigation works around Greeley, Denver, and in other localities. During this summer hundreds of square miles have been destroyed by fire—not simply burnt over but destroyed. The irrational treatment which this valuable property, still in the hands of the General Government, receives has been pointed out *ad nauseam.* The people in the San Joaquin Valley have at last begun to realize the influence of the wooded mountain crests upon their supply of water for irrigation, and have, in mass meetings, demanded the reservation and administration of these forest lands. The difficulty of devising

a proper system of protection and management, it is believed, is entirely overstated and with good will could no doubt be overcome.

(8) In the protection of these timber areas the judicious and systematic use of fire—burning over protective belts during the season of least danger—will reduce the need of forest guards.

(9) The reproduction of the coniferous woods of the West is in many localities not as readily accomplished as is desirable, the forest-floor having been destroyed by recurring fires, conditions for germination have been destroyed also. Large areas in the Colorado Mountains were seen without a sign of young growth. The red woods of California are doomed, it seems, to absolute extinction, for reproduction by seed is hardly noticeable, and the vigorous reproduction from the stump, in which this conifer excels all others (the ephemeral sprouts of *Pinus rigida* and *mitis* are of no account), seems not to find satisfactory conditions for development.

(10) During this trip the plantations made by the tree-planting machine, described in my last report, were visited and found to be superior to any others in the same locality (Stratton, Nebr.). They consisted largely of Russian mulberry planted three years, which for rapid soil-cover and hardiness seems a most commendable plant in that droughty region.

The policy of giving to the Chief of the Forestry Division an occasional opportunity to see a forest and to inspect the conditions of the country for which he is called upon to devise means of improvement may be considered not an unwise one. The more directly in touch he can be with the people and their wants the more practical will become his direction of the work. The objection to "book-learning" which is so often heard can only be overcome by giving liberal opportunity for personal observation.

During the year the office facilities have been somewhat increased. The herbarium, which was fortunately sufficiently advanced to furnish needed material upon the sudden call for an exhibit at the Paris Exposition, has been enlarged, as also the seed collection; so that soon these first requisites for a student of forest botany will be on hand. The library, too, has been further enlarged, and now the Forestry Division is perhaps the best equipped place in this country for students of forestry. This does not mean much, and room for improvement even in this direction is ample.

Besides Bulletin 3, on The Use of Metal Track on Railways, a second edition of Bulletin 2, on The Forest Conditions of the Rocky Mountains, became necessary and was printed. A circular on Arbor Day Planting, describing the proper methods of planting trees and giving advice on the selection of proper kinds, was issued early in the year.

SEED AND SEEDLING DISTRIBUTION.

In my former reports I have pointed out the perplexities which are experienced in trying to satisfy the requirement expressed in the appropriation for the division, "to collect and distribute valuable economic tree-seeds and plants." I have shown that, unlike most agricultural seeds, tree-seeds, as a rule, do not permit of long storage and in order not to lose their power of germination must be more carefully handled and more rapidly disposed of than the facilities of the Department permit; many desirable kinds, in fact, allow no handling at all but must be sown as soon as ripe. I have further shown that few people know how to handle tree-seeds in the seed-

bed, except the commonest and most easily grown kinds; that the length of time before a plantlet fit for transplanting is obtained will almost invariably weary the patience of the average settler; that distribution of plants while more cumbersome and costly is more likely to insure success, but that such distribution must be done under a well prepared plan, such as I have indicated in my report for 1887. The choice of plants instead of seeds is especially preferable for the droughty localities of the Western plains.

From the small amounts appropriated for the work of the division only insignificant sums can be spared for the purchase of seeds and seedlings; in fact, during the preceding year no purchases could be made, and therefore no distribution was made during this season. But a report was called for from those who had received seeds and seedlings the year before. These reports are most discouraging. A short synopsis of the reported results is herewith given, with some notes which show that nevertheless some desirable experience has been derived from these trials.

Report on tree-seed and seedling distribution, 1887–'88, *Forestry Division.*

NOTE.—The seedlings were sent out in packages of twenty-five each, with the exception of *Prunus serotina* (Black Cherry), of which only five were sent in a package. The column of "Total failures" indicates the number of reports showing entire want of success. To each applicant two or four packages of seed were usually sent, sometimes only one. The possibilities of success are indicated by marking in the column of "Best reports," the number of packages used in obtaining the specified number of seedlings.

DAKOTA.

Names of species.	Number of seedling reports.	Number of plants sent.	Per cent. living.	Total failures.	Number reporting success.	Per cent. of success.	Best report per cent.	Number of seed reports.	Packages of seed sent.	Seedlings from seed.	Best report number.
Pinus sylvestris (Scotch Pine)	23	575	7	18	5	32	*a*80	0	0	......	......
Pinus Austriaca (Austrian Pine)	23	575	5.22	17	6	20	*a*48	0	0	......	......
Pinus Strobus (White Pine)	16	400	5.25	13	3	28	*a*40	11	24	0	......
Pinus resinosa (Red Pine)	0	0	......	....	....	......	......	13	25	0	......
Pinus mitis (Short-leaved Pine)	0	0	......	....	....	......	......	0	0	......	......
Pinus ponderosa (Bull Pine)	0	0	......	....	....	......	......	5	6	0	......
Pinus laricio (Corsican Pine)	10	250	11.6	6	4	29	*a*40	10	20	0	......
Picea excelsa (Norway Spruce)	20	500	8.8	14	6	29.33	*a*80	0	0	......	......
Pseudotsuga Douglasii (Douglas Spruce)	9	225	0.9	8	1	8	8	9	16	300	1pk 300
Libocedrus decurrens (California White Cedar)	0	0	......	....	....	......	......	1	0	......	......
Juniperus Virginiana (Red Cedar)	0	0	......	....	....	......	......	10	22	0	......
Taxodium distichum (Bald Cypress)	0	0	......	....	....	......	......	0	0	......	......
Larix Europæa (European Larch)	19	475	9.47	13	6	30	*a*60	0	0	......	......
Fraxinus Americana (White Ash)	5	125	60	1	4	75	*b c*80	0	0	......	......
Fraxinus viridis (Green Ash)	7	175	44.6	2	5	62.4	*b c*80	15	31	325	2pks 100
Prunus serotina (Black Cherry)	5	25	48	2	3	16	*c*80	0	0	......	......
Gleditschia triacanthos (Honey Locust)	1	4	0	1	....	......	......	5	14	24	1pk 24
Robinia pseudacacia (Black Locust)	1	25	0	1	....	......	......	16	41	130	1pk 130
Catalpa speciosa (Hardy Catalpa)	3	75	25.3	0	3	25.33	*d*48	11	22	8	2pks 8
Acer dasycarpum (Silver-leaved Maple)	6	150	40	2	4	40	*b*80	0	0	......	......
Negundo aceroides (Box-Elder)	6	150	60.7	1	5	72.8	*b c*80	13	29	270	2pks 200
Maclura aurantiaca (Osage Orange)	1	4	0	1	....	......	......	1	4	0	......
Total	155	3,733	14.62	100	55	35.9	62	120	254	1,049	1pk 300

Report on tree-seed and seedling distribution, etc.—Continued.

NEBRASKA.

Names of species.	Number of seedling reports.	Number of plants sent.	Per cent. living.	Total failures.	Number reporting success.	Per cent. of success.	Best report per cent.	Number of seed reports.	Packages of seed sent.	Seedlings from seed.	Best report number.
Pinus sylvestris (Scotch Pine)	13	350	14	6	7	28	*e*80	0	0	......	......
Pinus Austriaca (Austrian Pine)	13	350	9.1	7	6	21.33	*i*32	0	0	......	......
Pinus Strobus (White Pine)	1	25	0	1	....	......	......	1	4	0	......
Pinus resinosa (Red Pine)	0	0	......	....	....	......	......	2	3	0	......
Pinus mitis (Short-leaved Pine)	0	0	......	....	....	......	......	0	0	......	......
Pinus ponderosa (Bull Pine)	0	0	......	....	....	......	......	3	4	0	......
Pinus laricio (Corsican Pine)	0	0	......	....	....	......	......	1	2	0	......
Picea excelsa (Norway Spruce)	1	25	16	....	1	16	*h*16	0	0	......	......
Pseudotsuga Douglasii (Douglas Spruce)	9	225	24.4	5	4	55	*e f*84	2	3	0	......
Libocedrus decurrens (California White Cedar)	0	0	......	....	....	......	......	1	1	0	......
Juniperus Virginiana (Red Cedar)	0	0	......	....	....	......	......	2	8	0	......
Taxodium distichum (Bald Cypress)	0	0	......	....	....	......	......	0	0	......	......
Larix Europæa (European Larch)	1	25	0	1	....	......	......	....	....	......	......
Fraxinus Americana (White Ash)	0	0	......	....	....	......	......	0	0	......	......
Fraxinus viridis (Green Ash)	3	75	60	0	3	60	*g j*80	2	6	0	......
Prunus serotina (Black Cherry)	1	5	80	0	1	80	*g*80	....	....	......	......
Gleditschia triacanthos (Honey Locust)	1	25	20	0	1	20	*h*20	1	4	11	4pks 11
Robinia pseudacacia (Black Locust)	1	25	4	0	1	4	4	2	8	20	4pks 20
Catalpa speciosa (Hardy Catalpa)	11	275	62.9	1	10	55.64	*b g*100	1	2	400	2pks 400
Acer dasycarpum (Silver-leaved Maple)	1	25	24	0	1	24	*g*24	0	0	......	......
Negundo aceroides (Box-Elder)	1	25	80	0	1	80	*g*80	2	6	500	2pks 500
Maclura aurantiaca (Osage Orange)	0	0	......	....	....	......	......	1	4	0	......
Total	57	1,455	26.06	21	36	40.36	54.5	21	55	931	2pks 500

KANSAS.

Names of species.	Number of seedling reports.	Number of plants sent.	Per cent. living.	Total failures.	Number reporting success.	Per cent. of success.	Best report per cent.	Number of seed reports.	Packages of seed sent.	Seedlings from seed.	Best report number.
Pinus sylvestris (Scotch Pine)	29	725	3.4	17	12	8.33	*k*40	0	0	......	......
Pinus Austriaca (Austrian Pine)	28	700	0.57	25	3	5.33	*k*8	0	0	......	......
Pinus Strobus (White Pine)	5	125	0	5	....	......	......	6	24	0	......
Pinus resinosa (Red Pine)	0	0	......	....	....	......	......	6	12	0	......
Pinus mitis (Short-leaved Pine)	0	0	......	....	....	......	......	0	0	......	......
Pinus ponderosa (Bull Pine)	0	0	......	....	....	......	......	6	12	0	......
Pinus laricio (Corsican Pine)	5	125	0	5	....	......	......	4	8	0	......
Picea excelsa (Norway Spruce)	0	0	......	....	....	......	......	0	0	......	......
Pseudotsuga Douglasii (Douglas Spruce)	13	325	.61	11	2	4	*m*4	1	2	0	......
Libocedrus decurrens (California White Cedar)	0	0	......	....	....	......	......	6	6	0	......
Juniperus Virginiana (Red Cedar)	0	0	......	....	....	......	......	6	14	0	......
Taxodium distichum (Bald Cypress)	0	0	......	....	....	......	......	5	20	0	......
Larix Europæa (European Larch)	0	0	......	....	....	......	......	0	0	......	......
Fraxinus Americana (White Ash)	0	0	......	....	....	......	......	0	0	......	......
Fraxinus viridis (Green Ash)	4	100	21	0	4	21	*l n*32	7	13	302	2pks 300
Prunus serotina (Black Cherry)	1	5	0	1	....	......	......	0	0	......	......
Gleditschia triacanthos (Honey Locust)	5	125	41	1	4	55	*l*76	3	7	74	4pks 60
Robinia pseudacacia (Black Locust)	0	0	......	....	....	......	......	6	12	300	2pks 300
Catalpa speciosa (Hardy Catalpa)	24	600	50.5	5	19	62.1	*k l m n* 100	6	12	71	2pks 70
Acer dasycarpum (Silver-leaved Maple)	1	25	1	0	1	4	*l*4	2	3	0	......
Negundo aceroides (Box-Elder)	1	25	80	0	1	80	*l*80	7	13	450	1pk 250
Maclura aurantiaca (Osage Orange)	....	......	......	....	....	......	......	....	....	......	......
Total	116	2,880	14.76	70	46	29.83	43	71	155	1,197	1pk 250

Report on tree-seed and seedling distribution, etc.—Continued.

COLORADO.

Names of species.	Number of seedling reports.	Number of plants sent.	Per cent. living.	Total failures.	Number reporting success.	Per cent. of success.	Best report per cent.	Number of seed reports.	Packages of seed sent.	Seedlings from seed.	Best report number.
Pinus sylvestris (Scotch Pine)	20	500	8.4	15	5	35.2	*o r s* 64	0	0	......	......
Pinus Austriaca (Austrian Pine)	20	500	9.6	13	7	27.42	*o q* 48	0	0	......	......
Pinus Strobus (White Pine)	1	25	0	1	....	......	......	0	0	......	......
Pinus resinosa (Red Pine)	0	0	......	....	....	......	......	13	26	800	2pks 800
Pinus mitis (Short-leaved Pine)	0	0	......	....	....	......	......	0	0	......	......
Pinus ponderosa (Bull Pine)	0	0	......	....	....	......	......	12	23	300	2pks 300
Pinus laricio (Corsican Pine)	1	25	0	1	....	......	......	1	2	0	......
Picea excelsa (Norway Spruce)	0	0	......	....	....	......	......	0	0	......	......
Pseudotsuga Douglasii (Douglas Spruce)	14	350	5.7	12	2	4	*o* 72	0	0	......	......
Libocedrus decurrens (California White Cedar)	0	0	......	....	....	......	......	12	12	0	......
Juniperus Virginiana (Red Cedar)	0	0	......	....	....	......	......	13	28	0	......
Taxodium distichum (Bald Cypress)	0	0	......	....	....	......	......	2	8	0	......
Larix Europæa (European Larch)	0	0	......	....	....	......	......	0	0	......	......
Fraxinus Americana (White Ash)	0	0	......	....	....	......	......	1	1	37	1pk 37
Fraxinus viridis (Green Ash)	8	200	31	4	4	62	*p q* 100	14	28	2,100	2pks 2,000
Prunus serotina (Black Cherry)	1	5	20	0	1	20	*p* 20	0	0	......	......
Gleditschia triacanthos (Honey Locust)	13	325	29.8	6	7	55.43	*o r s* 100	1	4	0	......
Robinia pseudacacia (Black Locust)	0	0	......	....	....	......	......	12	26	1,512	2pks 1,500
Catalpa speciosa (Hardy Catalpa)	7	175	33.14	3	4	58	*p q* 100	14	51	845	2pks 800
Acer dasycarpum (Silver-leaved Maple)	0	0	......	....	....	......	......	......	0	0	......
Negundo aceroides (Box-Elder)	1	25	100	0	1	100	*p* 100	12	24	1,615	2pks 1,500
Maclura aurantiaca (Osage Orange)	....	......	......	....	....	......	......	......	....	......	......
Total	86	2,130	16.66	55	31	32.73	75.5	107	233	7,209	2pks 2,000

Localities of best reports: *a* New Salem. *b* Cavour and Sioux Falls. *c* Doland. *d* Glen Ullin. *e* Paxton and Newport. *f* Fleming. *g* Rushville. *h* Capay. *i* Newport. *j* Stratton. *k* Portland. *l* La Blanche. *m* Dermot. *n* Griswold. *o* Fort Collins. *p* Pueblo. *q* Rocky Ford. *r* Colorado Springs. *s* Hudson.

Only a limited number of reports have been returned and only those received from the four States appearing in the table did it seem worth while to tabulate.

Most of the reports, it should be stated, refer to hail or unusual drought during the last two seasons as producing the failures.

The column "best result" gives an indication of what individual success was possible. In fact the table shows most clearly that success, if we call success 40 per cent. saved through two years of unfavorable weather, was attainable in most cases by and is due to individual effort or knowledge. Thus of twenty-three reporting on Scotch pine in Nebraska, only five had any success; but while these together saved forty plants (32 per cent. of what they received), one of them reports 80 per cent. or twenty plants living, leaving only twenty plants to the other four.

The same applies to success with seeds. Of nine applicants receiving sixteen packages of seed of Douglas Spruce only one was successful, raising three hundred plants from one package; and so it will be found that in almost every case the success was with one man,

showing that failure could have been avoided and was not necessarily due to uncontrollable conditions.

The locality in which the best success (above 40 per cent.) with each species was obtained is denoted in foot notes.

Altogether, more total success is reported from Nebraska than from the other States, although individual success was greatest in Dakota. It may be noted, that of the conifers the Scotch Pine did best, and next to it the Douglas Spruce, with 84 per cent. in Nebraska and 72 in Colorado.

This tree also, together with the Red Pine and Bull Pine gave results, each in one case, from the seed. Of deciduous trees the Catalpa shows the most uniform success, except in Dakota, where it is perhaps out of its range.

There can be only three objects in the distribution of plant material which are worthy and desirable for the Department to attain: either to give aid to and stimulate by it the efforts of forest planters, to test the adaptability of certain kinds to certain localities, or to introduce new desirable species and facilitate the use of certain kinds which have not found favor for some reason outside of their intrinsic value—such as high price, difficulty of obtaining seed, slow growth, etc.

The first object can of course only be attained by giving sufficiently large quantities of plants of acknowledged value. How futile it would be on the part of the Department, with its present appropriations, to distribute plant material with this object in view, will appear readily from an inspection of the subjoined table, exhibiting the number and acreage of timber-culture entries. There are now on the average 25,000 claims entered annually. Even if the distribution were confined only to these planters and not more than the material for one acre were furnished—a small enough encouragement—the amount to be spent in that direction would have to be not less than $150,000.

If the introduction of untested kinds is the object, then, as the foregoing synopsis of reports may show, the distribution should go only to experienced planters, who can give proper attention and are able to judge whether failure is due to external causes which may be controlled, or to inherent qualities of the species tested. The third object, namely, to facilitate the introduction of kinds difficult to obtain, would tax the financial conditions of the division for only a small result. Yet this consideration is a proper one, and has somewhat directed the selection of the material which has been used for distribution. Thus seeds of two valuable *Acacias* were obtained from Australia, and seeds of *Abies Nordmanniana* from Asia Minor, the latter now recognized as by all means the best fir for ornament, timber, or hardiness. Of native trees, the Bald Cypress (*Taxodium distichum*), a tree of our Southern swamps, has proved better than was hoped for, namely, that it is drought-proof and a most rapid grower even on the uplands of Texas. The wild black cherry was also selected for distribution, as it promises to become one of the most promising trees for Western planting. The Bull Pine (*Pinus ponderosa*) and the Douglas Fir (*Pseudotsuga Douglasii*), the most prominent conifers of the Rocky Mountain region, which should have a full trial in the plains country, have been secured for distribution this season. It is objected, and quite properly, that conifer seeds are too difficult for the inexperienced planter to handle, and

that it would be preferable to send well-rooted plants. It is therefore proposed to send these seeds largely to Experiment Stations, through the medium of which the plants could be distributed when grown, in the same manner as is now done at the California Experiment Station, by charging enough to cover the cost of packing and postage. A small assortment of seeds of the various more commonly planted trees, in half-ounce and ounce packages, is also kept on hand to satisfy applications.

TIMBER-CULTURE ACT.

It seems proper for this division to keep a watchful eye on any movement that promises an increase of forest area and to note especially the working of the timber-culture act, as far as it promises to clothe the treeless plains with a forest cover. The following compilation of the status of timber-culture entries from the reports of the General Land Office one would be inclined to think would furnish, at least approximately, an idea of the area planted to timber; but since it may be said that the majority of these entries have not only changed hands, and thus appear in the annual statements repeatedly, but have also been changed to entries of other kinds, no conception of the actual area planted can be gained from the study of these figures. They do show, however, that even with these conditions, which tend to increase the figures, the results of the act are so far not satisfactory. An analysis of the figures shows that 38,080,506 acres were entered under the timber-culture act up to June 30, 1888. This should represent a planted area of 2,380,030 acres, if the law were complied with and the entries not changed. Allowing ten years for timber-claim planters to prove up their entries (the law places it at eight years, allowing extensions on account of failures), the entries of the first six years, 1873 to 1878, alone give us some points of comparison for the estimation of results. During that time 3,821,843 acres were proved up, representing an area of less than 50,000 acres planted to timber.

From this it would appear that the timber-culture act has been a failure, so far as the creating of forests is concerned.

It is asserted that a better percentage will be obtained from the entries of later years, because more experience has been gained, and timber-claim planting is now done under contract by persons who make a business of it. Yet the consensus of unbiased testimony goes to show that timber-claim planting, as a rule, does not produce the results sought after, and has mostly been used as a means for speculation in Government lands, partly with that design from the beginning, partly as a necessity after failure to obtain the land by timber planting.

There is also considerable planting of wind-breaks and groves done on homesteads, which is said to be attended with better results. Altogether, however, the amount of tree planting is infinitesimal, if compared with what is necessary for climatic amelioration; and it may be admitted, now as well as later, that the reforestation of the plains must be a matter of co-operative if not of national enterprise.

Original and final entries under the timber-culture act.

State or Territory.	1873—Original.		1874—Original.		1875—Original.		1876—Original.		1877—Original.	
	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.
Arizona	...	...	2	196	2	320	10	1,197	21	2,440
Arkansas	...	...	...	...	...	...	3	231	...	...
California	2	329	59	8,878	195	29,065	136	20,524	75	10,586
Colorado	...	...	17	2,272	27	3,453	45	6,514	28	3,343
Dakota	24	3,560	865	124,997	451	61,969	842	119,835	476	68,266
Idaho	...	...	2	180	21	2,583	17	1,973	52	7,035
Iowa	1	145	33	3,816	92	9,127	99	8,563	59	4,791
Kansas	60	9,642	1,954	282,479	1,265	168,269	1,354	185,596	1,666	238,020
Louisiana	...	...	...	...	...	...	...	...	...	...
Minnesota	95	14,710	804	113,131	499	63,673	1,070	140,126	561	76,021
Montana	...	...	...	...	...	...	...	...	3	398
Nebraska	137	21,858	2,264	312,712	1,061	130,894	834	106,499	706	90,812
Nevada	...	...	...	...	...	...	...	...	2	240
New Mexico	...	...	...	...	...	...	7	1,128	...	...
Oregon	...	...	...	...	7	882	13	1,793	19	2,509
Utah	...	...	...	...	...	...	3	399	3	338
Washington	...	...	22	2,482	31	3,324	54	5,374	148	19,746
Wyoming	...	...	1	80	1	130	1	160	...	...
Total	319	50,244	5,923	851,223	3,652	473,689	4,488	599,912	3,819	524,545

State or Territory.	1878—Original.		1879—Original.		1880—Original.		1881—Original.	
	No.	Acres.	No.	Acres.	No.	Acres.	No.	Acres.
Arizona	11	1,600	21	3,280	6	719	6	760
Arkansas	...	...	...	...	...	...	...	...
California	60	8,029	112	14,458	99	12,120	201	24,538
Colorado	125	17,436	121	16,142	214	30,302	195	26,473
Dakota	...	...	4,675	728,687	5,575	868,748	5,133	868,400
Idaho	158	22,169	162	22,013	181	23,300	224	28,680
Iowa	89	7,535	73	6,577	57	4,714	55	3,643
Kansas	4,031	593,295	7,776	1,167,582	2,891	408,261	1,924	268,575
Louisiana	...	...	1	80	1	40	19	2,293
Minnesota	2,693	377,017	1,847	257,642	909	123,735	1,168	167,582
Montana	9	960	27	3,134	61	6,835	131	16,535
Nebraska	1,408	195,306	3,183	465,968	3,202	475,275	1,682	240,306
Nevada	5	600	1	160	5	560	7	1,040
New Mexico	2	320	14	1,891	24	2,887	16	2,039
Oregon	130	18,446	117	17,046	482	73,061	212	31,176
Utah	9	1,280	20	2,328	35	4,044	35	3,921
Washington	562	78,237	479	68,506	893	134,637	540	77,008
Wyoming	...	...	...	...	9	240	5	784
Total	9,292	1,322,230	18,629	2,775,494	14,644	2,168,478	11,553	1,763,754

State or Territory.	1882.				1883.				1884.			
	Original.		Final.		Original.		Final.		Original.		Final.	
	No.	Acres.	No.	Acres	No.	Acres.	No.	Acres	No.	Acres.	No.	Acres
Arizona	9	1,352	...	...	33	4,336	...	...	41	5,483	...	...
Arkansas	...	...	...	...	...	...	...	...	1	80	...	...
California	306	39,88[illegible]	...	...	327	44,670	1	160	535	72,319	1	160
Colorado	329	47,436	...	...	413	58,685	...	...	917	137,933	1	160
Dakota	9,368	1,446,532	4	521	1,199	1,755,419	111	14,968	11,279	1,748,640	166	21,470
Idaho	272	33,965	...	...	310	40,105	...	...	407	56,171	1	180
Iowa	82	6,235	...	...	42	3,373	20	2,165	45	3,346	27	2,794
Kansas	1,933	273,053	71	9,915	1,690	237,860	185	24,965	2,738	397,525	181	23,093
Louisiana	7	1,004	...	...	52	7,754	...	...	265	38,788	...	...
Minnesota	1,220	176,741	21	2,998	883	122,750	84	11,495	689	95,538	90	12,324
Montana	266	35,409	...	...	403	53,952	...	...	471	63,283	...	...
Nebraska	2,806	293,520	68	9,975	3,216	481,704	317	43,522	2,933	1,068,189	239	30,040
Nevada	10	1,520	...	...	2	280	...	...	1	159	...	...
New Mexico	34	3,351	...	...	159	22,091	...	...	131	17,945	...	...
Oregon	590	88,038	...	...	767	116,334	2	240	978	148,356	1	160
Utah	32	3,831	...	...	62	7,509	...	...	86	11,192	...	...
Washington	603	87,[illegible]24	...	...	944	139,737	3	320	1,158	173,142	7	914
Wyoming	20	2,284	...	...	98	14,204	...	...	321	46,027	...	...
Total	17,877	2,546,677	164	23,409	10,600	3,111,763	723	97,835	22,996	4,084,116	714	91,295

Original and final entries under the timber-culture act—Continued.

State or Territory.	1885.				1886.			
	Original.		Final.		Original.		Final.	
	No.	*Acres.*	*No.*	*Acres.*	*No.*	*Acres.*	*No.*	*Acres.*
Arizona	134	19,542	1	160	113	15,772	1	160
Arkansas	4	640	.....	.....	19	2,025	.....	.....
California	592	9,406	3	480	1,136	155,674	.....	.....
Colorado	1,356	20,498	2	240	4,598	719,947	4	559
Dakota	8,499	1,328,966	161	21,207	7,030	1,098,958	275	39,591
Idaho	372	48,255	.....	.....	386	49,959	2	240
Iowa	63	3,647	17	1,437	44	2,869	13	1,014
Kansas	7,557	1,169,303	214	27,133	12,193	1,920,802	315	42,657
Louisiana	110	15,598	.....	.....	72	9,914	.....	.....
Minnesota	604	79,410	109	13,618	507	65,026	174	24,311
Montana	304	41,207	.....	.....	324	43,031	1	160
Nebraska	9,436	1,468,114	190	25,037	6,234	969,706	215	28,278
Nevada	.....	.....	.....	.....	1	120	.....	.....
New Mexico	125	16,286	.....	.....	123	15,603	.....	.....
Oregon	664	97,331	1	160	651	93,160	6	880
Utah	127	15,842	1	80	200	25,632	.....	.....
Washington	561	81,851	51	1,017	597	85,645	30	3,920
Wyoming	460	67,243	.....	.....	663	100,167	.....	.....
Total	30,968	4,483,139	750	90,569	34,891	5,374,010	1,036	141,770

State or Territory.	1887.				1888.			
	Original.		Final.		Original.		Final.	
	No.	*Acres.*	*No.*	*Acres.*	*No.*	*Acres.*	*No.*	*Acres.*
Arizona	144	20,199	2	320	303	45,374	.....	.....
Arkansas	7	840	.....	.....	5	600	.....	.....
California	1,168	165,382	1	40	1,668	240,216	1	49
Colorado	9,092	1,427,626	4	559	6,173	970,281	7	760
Dakota	4,194	650,420	387	57,311	4,037	626,629	202	29,996
Idaho	306	38,912	3	400	387	51,717	9	891
Iowa	60	4,945	15	1,207	37	2,187	32	2,888
Kansas	4,405	685,137	157	21,881	4,746	732,545	421	56,502
Louisiana	65	9,402	.....	.....	80	11,469	.....	.....
Minnesota	395	52,306	165	25,009	433	56,622	118	15,003
Montana	282	38,847	2	280	274	36,407	1	39
Nebraska	5,310	794,[illegible]	379	52,541	4,277	660,915	345	48,264
Nevada	4	640	.....	.....	4	560	.....	.....
New Mexico	168	23,605	.....	.....	266	39,692	3	226
Oregon	643	93,137	8	920	855	126,979	29	4,436
Utah	179	21,638	1	160	257	30,234	4	420
Washington	482	67,563	54	7,686	509	89,980	49	6,816
Wyoming	492	69,814	.....	.....	360	53,260	.....	.....
Total	27,366	4,175,565	1,198	168,314	24,761	3,775,667	1,221	166,390

SUMMARY.

State or Territory.	Original entries.		Final entries.	
	No.	*Acres.*	*No.*	*Acres.*
Arizona	856	122,570	4	640
Arkansas	39	4,416	.....	.....
California	6,671	856,076	7	889
Colorado	23,650	3,498,351	18	2,278
Dakota	63,647	11,500,026	1,306	185,064
Idaho	3,257	427,017	15	1,711
Iowa	931	75,514	124	11,505
Kansas	58,183	8,738,944	1,544	206,146
Louisiana	672	96,312	.....	.....
Minnesota	14,377	1,882,020	781	104,758
Montana	2,555	339,098	4	479
Nebraska	48,589	7,780,825	1,753	237,657
Nevada	42	5,879	.....	.....
New Mexico	1,059	146,928	3	326
Oregon	6,128	903,248	47	6,796
Utah	1,048	128,188	6	660
Washington	7,673	1,114,761	194	20,673
Wyoming	2,401	454,393	.....	.....
Total	241,778	38,080,506	5,806	770,582

OSIER CULTURE.

In my report for 1886 there was given a brief instruction for osier-growing and a fuller manual was promised. The manuscript of this manual has remained unfinished and unpublished for want of sufficient knowledge to write the chapter on the selection of kinds to be grown. This knowledge can only be obtained by actual experiment, for which, at the time and since, the Department did not have the means or facilities. By private endeavor of the writer, and through the favor of a prominent osier-grower in Austria, Heinrich Ritter von Manner, a selection of rods of some seventy varieties was obtained in the spring of 1887, and cuttings were distributed to the various experiment stations.

The long journey, absence of facilities to readily prepare and send the cuttings from here, and the consequent delay in reaching their destination proved detrimental to a large number, and in most cases the experiment stations which have been heard from report entire failure. Yet the reports from the Agricultural College, Michigan; State College, Pennsylvania, and the Agricultural Experiment Stations at Berkeley, Cal., indicate that these stations have been able to save quite a number. Mr. Sudworth, of this division, secured space in some private grounds and planted the full selection, with the results as stated in table below.

The report of Professor Hilgard, of California, is specially satisfactory, as he has been able to grow nine varieties in sufficient quantities to announce a distribution of plant material in lots of ten cuttings of a kind for 10 cents or 1 dozen assorted at 20 cents. He does not, however, propose to extend this distribution beyond the limits of his State.

These experiments, although giving no definite answer as yet either in regard to adaptability to our climate or the basket-making properties of these varieties when grown under our hot sun, have yet given an indication that the repetition of this introduction would be a proper course for the Department. It should be added that the plants (except probably those in California) were not cut down as they should have been after the first season. The largest number were saved at State College, Pennsylvania. Professor Buckhout reports fifty-nine alive, although more than half in poor condition, and says:

> The cuttings came wrapped in oiled paper and in good condition; they were put out in rows 6 inches apart in the row, and have received ordinary cultivation and light hoeing, such as is usually given to nursery stock; soil, rather heavy clay loam with flint gravel; high uplands.

The Roman numbers in the table refer to varieties which are more commonly used in Europe.

Results of growing

Register number.	Name.	Pennsylvania. Height.		Pennsylvania. Remarks on growth.*
		Ft.	*in.*	
I	Salix amygdalina canescens	1	6	Poor growth
III	Salix amygdalina latifolia	1	3	......do
57	Salix amygdalina palida	2		Stout (one-half inch) and fairly vigorous
59	Salix amygdalina spadicea		6	Very poor growth
60	Salix amygdalina regalis		6	......do
61	Salix amygdalina lutea		6	......do
66	Salix amygdalina inflexa	1	3	Poor growth
67	Salix amygdalina italica nigra	1		......do
69	Salix amygdalina erecta			
70	Salix amygdalina crispifolia	1	6	Fair growth
71	Salix amygdalina picta	1	3	......do
72	Salix amygdalina italica alba	1		Poor growth
114	Salix amygdalina pyrifolia	2	6	Good growth and tough
139	Salix amygdalina supera			
81	Salix alba flora	2	6	Good growth and tough (yellow bark)
83	Salix alba vitellina	2	6	......do
87	Salix alba casteriana	1		Poor growth
112	Salix hastata	2	6	Good growth and tough (yellow orange).
21	Salix fragilis	2		Good growth
22	Salix fragilis pentandra	2		......do
37	Salix purpurea	5		Good growth, slender, tough
XXI	Salix purpurea (Stone Willow)			
38	Salix purpurea (wild, from Danube)			
24	Salix purpurea pyramidalis	3		Good growth
29	Salix purpurea Kerksii	3		......do
30	Salix purpurea gracilis	3		......do
IV	Salix purpurea × viminalis	1		Poor growth
25	Salix Helix	2		Good growth
131	Salix uralensis (from Galicia)	4		Good growth, slender, tough (red-gray).
35	Salix uralensis serotina	1	6	Poor growth
44	Salix rubra viridis	1	3	......do
116	Salix rubra cinnamomea	2	6	Good growth and tough
X	Salix viminalis (Belgian)			
XI	Salix viminalis (Rough Golden)	1	6	Fair growth
XII	Salix viminalis (Rough Red)	1	6	......do
XIII	Salix viminalis (Smooth Golden)	2		......do
XIV	Salix viminalis (Rough Green)	2	6	......do
XV	Salix viminalis (high-growing varieties)			
143	Salix viminalis (French)	1		Poor growth
144	Salix viminalis (English Longskin)	1	3	......do
6	Salix viminalis alba	1		Very poor growth
9	Salix viminalis stricta	1	6	Fair growth
14	Salix viminalis meliorata			
16	Salix viminalis patula		6	Very poor growth
142	Salix viminalis nobilis			
XXX	Salix hippophaëfolia	1	6	Fair growth

* Cuttings arrived in good condition. Set in rows 6 inches apart in the row, and receiving ordinary cultivation and light hoeing. Soil rather heavy clay loam with flint gravel; high upland, with no extra moisture or periodic overflow.

varieties of Osiers.

Washington, D. C.		California.	Michigan.	
Height.	Remarks on growth.†	Remarks on growth.	Height.	Remarks on growth.
Ft. in.			*Ft in.*	
8	Very stout (one-half to one inch) much branched, bush-like.			
1 6	Slender, producing clean rods	Rather small rods; wood hard (dark green bark).		
3 10	Slightly branched, but tending to produce good rods.			
8 6	Producing clean slender rods			
3 6	Slightly branched, but mostly good rods.			
3 6	do		1	
6	do			
7	do			
3 8	do			
3 6	do			
7 6	Producing clean slender rods			
4	do			
4 8	do			
4 6	do			
			4 6	Soil usually moist, but dry in 1889. Well cultivated and hoed. Some plants set too near other small trees. A number of other species are still alive, but with growth of less than one foot.
9	Producing clean slender rods			
3	Slightly branched, but mostly good rods.			
5 9	do			
6 0	Producing clean slender rods		4	
7	do			
1 6	Stunted and branched; suffered from drought.		1	
7 6	Slightly branched, but mostly good rods.		2	
		Strong grower (bark greenish yellow).	2	
			2 6	
			4	
		Rather small, slim growth (bark greenish yellow).		
3	Slightly branched, but mostly good rods.		3	
		Long rods (bark greenish yellow).		
3 6	Slightly branched, but mostly good rods.			
3 10	do		2 6	
3 6	do			
2 10	do			
		Medium grower (bark greenish yellow).		
5	Producing clean slender rods			
		Strong grower (bark greenish yellow).		
5 3	Slightly branched, but mostly good rods.	Strong grower (reddish bark).		

† Cuttings placed in water 36 hours before planting. Soil rather sandy clay loam; upland moderately rich. Situation, north side of 9-foot tight board fence. Ground roughly spaded; cuttings set in row 6 inches apart. No care was given the cuttings after planting, except pulling of rank weeds tending to choke the willows, and cutting of grass and weeds on either side of row once during the season.

It is to be understood that of the numberless varieties of willows, not all are Osier Willows fit for basket-work; and again, of those which grow rods fit for such work, there are some adapted to coarse work only, while others can be used in the finer ware. The fine ware is at present almost entirely imported, the reason being partly the absence of proper material grown in this country and partly, probably, labor conditions.

The native willows are locally used for basket-work of indifferent quality, but it is not known at this office that they are grown for profit, and they have not been but ought to be tested as to their qualities for profitable Osier growing.

The requirements for a good Osier Willow are, that it produce many slender rods without branching, that the rods be soft and pliable, that the rods when peeled be of white color preferably, that the stocks will re-produce for a long time and vigorously.

Of the European kinds, the *Salix purpurea* (Red Osier) is mostly grown in this country, but evidently under the climatic conditions of some parts of our country it does not thrive as well as in Europe. The hot sun and the cold winters seem specially to influence the hardness of the rod, reducing the pith to a minimum, while the desirable rod must be soft, pliable, and have a large pith, and when peeled show along the rod only small closed eyes; the open elongated eyes being a sign of weakness. In new introductions, especially into the Southern and Middle States, the softest kinds should be looked to first, as they will harden anyhow.

The letters asking for advice in Osier culture and inquiries as to its profitableness are becoming more and more frequent, probably because it is believed to be a simple and easy means of starting a very profitable business. I have seen no reason to change my opinion, expressed in the report for 1886, that it is mainly a ready market and labor conditions which make Osier growing profitable in some localities, such as Syracuse, St. Louis, Cincinnati, Chicago, around New York, etc.

The salt manufacture around Syracuse, for instance, employs a large number of hands during the summer who would be out of employment during the winter if they had not basket-making to fall back upon; only few basket-makers work all the year round at their trade.

A few figures regarding the profit of Osier growing, obtained from the neighborhood of Syracuse, may be of interest. It is estimated that 5,000 people are more or less engaged in the business in that region, and the manufacture amounts to about 28,000 dozen baskets. One man will make eight baskets per day; three sizes of clothes baskets—hardly any other—are made, and the price for making is from $1.70 to $1.80 per dozen. The average quantity of rods needed per dozen of the smaller baskets is 20 pounds, a little more for larger.

The total cost for basket-making may be figured as follows:

Cost of 1 ton of green rods	$15.00
Steaming and hauling to and from steam-box	2.25
Stripping	8.00
Making into baskets (14 dozen)	26.25
Cost of 14 dozen	51.50
Cost per dozen	3.67

As to the yield of the osier-holts around Syracuse, 4 tons of green rods per acre is an average crop, 6 tons a very good yield, and 8 tons have been occasionally obtained. The price per ton, green, has fallen from $20 to $15, while dry rods stripped will bring $60 per ton. For steaming $1 to $1.50 per ton is paid, and for stripping $6 to $8; 2 to 2½ tons, green, yielding one ton of dry rods. Most of the rods are steam-peeled, which causes them to lose their whiteness and makes them less valuable; the steam is applied in boxes containing half a ton, in which the rods are steamed for ten hours. Sap-peeled rods are superior, in color at least, but require more care; they are cut in winter and kept in water for three weeks, when they may be peeled easily.

As to the methods of growing, I may refer to the report for 1886.

In brief, the following points for establishing a good osier-holt may be repeated. A fresh soil, but by no means a wet one, thoroughly prepared to at least 16-inch depth by ditching and bringing the top soil to the bottom. Planting 12-inch long cuttings in early spring, making the rows 24 inches apart, the cuttings 4 inches in the row, which requires in round figures 65,000 cuttings per acre, costing about $5 per thousand. Shallow cultivation to keep down weeds is required several times during the year; surface manuring is desirable. Cutting the rods down during the winter as close as possible to the ground with a smooth cut is desirable even after the first season, in order to get long, thin, and branchless rods the next year. A well-kept holt will increase in yield the first three years, then gradually decline, until it becomes unprofitable and must be newly planted after fifteen or sixteen years.

FORESTRY INTERESTS IN THE UNITED STATES.

Limited space permits only brief mention of the most notable events in the progress of forestry reform through the country during the last year.

Early in the year and soon after its annual meeting at Atlanta, Ga., a committee of the American Forestry Congress waited upon President Harrison and presented a memorial urging the adoption of an efficient Government policy for the preservation and protection of the public forests, and expressing the hope that the President would call the attention of Congress to the subject with a favorable recommendation of the action which was desired by the Forestry Congress.

At the meeting of the Forestry Congress (now having changed its name to that of the Forestry Association) at Philadelphia, in October last, a petition to Congress was adopted, urging the passage of an act withdrawing from sale all forest lands belonging to the nation, and committing them to the custody of the Army, until a commission shall have determined what regions should be kept permanently in forest and shall have presented a plan for a national forest administration. The appointment of such a commission through the President and necessary appropriations were also asked for.

The desirability of having a course of instruction in forestry at the agricultural colleges and of forestry experiments at every experiment station formed the subject of another resolution.

It deserves to be noticed also that the American Association for the Advancement of Science, at its meeting in August, at Toronto,

appointed a committee to represent the forestry interests of the nation to Congress.

Pursuant to the action of the Forestry Association, a forcibly written memorial has been addressed to the United States Congress, asking that the public lands in the arid regions of the West be withdrawn from sale, until it can be determined what portion of them are situated within the natural water-sheds of streams; that these be placed in the custody of the Department of Agriculture, the timber only thenceforth to be sold and the land kept as a permanent forest reserve.

A similar memorial has recently been presented to Congress by a committee appointed at a convention of the citizens of Fresno, Tulare, Kern, and Merced Counties, of California, asking for the permanent protection of the forests lying upon the water-sheds of those counties.

A memorial prepared by the State Board of Forestry of California presents the same requests in a broader application.

A movement has also been made in Colorado for the establishment of a public park in that State, a principal object of the movement being the preservation of the forests of a region which is the source of several large streams.

The fourth annual report of the Ohio Forestry Bureau shows a gratifying progress in advancing the interests of forestry in that State.

In Pennsylvania, although the Forestry Association failed to secure from the legislature the establishment of a permanent Forest Commission, they were successful in obtaining the repeal of the fence law, which had been upon the statute-book ever since the year 1700; a law which left the forests of the State largely exposed to the intrusion of cattle and their consequent injury. The repeal of the law will be of great advantage to the forests which remain.

In New York the report of the Forest Commission for 1888 indicates the need of a change in the laws in regard to the redemption of the land and the cancellation of the titles, in order to prevent the loss by the State of much land, valuable as a part of the forest reserve, which recent enactments have been designed to secure. The commission also asks that the further extension of railroads in the counties embraced within the forest reserve shall not be allowed, as such extension can not be regarded otherwise than as a calamity. They also ask for such an appropriation from the State treasury as will enable them to purchase, for the purpose of increasing the forest domain, such forest lands as can be bought at a fair valuation.

In New Hampshire, the last legislature established a commission "to examine and ascertain the feasibility of the purchase by the State of the whole or any portion of the timber lands upon the hills or mountains of the State, near summer resorts, or bordering upon the principal sources of the water supplies needed for manufacturing purposes, with a view of preserving the same as public lands and parks." The commission is organized and actively at work.

In Massachusetts a notable forestry movement has been made by the town of Lynn. At the first settlement of the State Lynn, the second town established in it, had a wild piece of woodland which was held in common until 1706, the proprietors being free to enter it and cut fuel and timber to supply their needs. At the date mentioned the tract was divided among the land-owners. It is a region

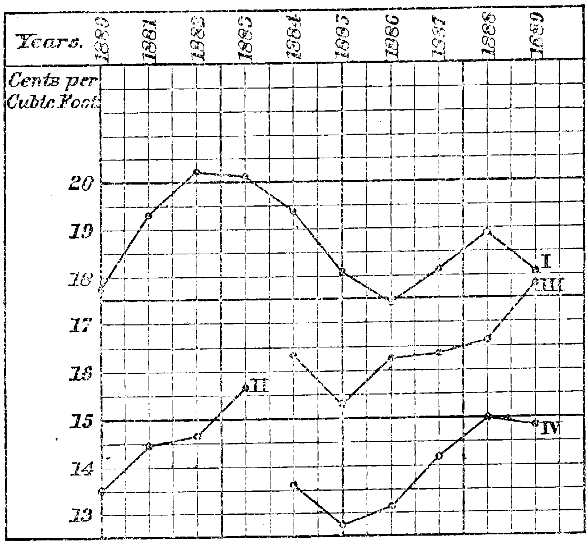
of rock-ribbed hills with bold ledges and precipitous crags, the intervening glens and valleys coursed by clear and rapid brooks and rills and having in their depths extensive swamps and ponds. It is now to return to its original character of a woodland held in common, and be, in addition, a free pleasure-ground. The city council lately decided to take advantage of the public park act of Massachusetts (see report of this division, 1887, page 101), and made an appropriation of $30,000 for the purchase of the land, which, with private subscriptions, gives a fund of about $450,000 for the purpose. A board of park commissioners, evidently the right men for the place, has been appointed, and they are now taking the land by right of eminent domain. The park commission, the water board, and the public forest trustees will act in harmony in the administration of the region as a public forest—which it will be pure and simple, with no attempt to incorporate the ordinary park features into its plan. There are about 800 acres to be taken, which, with that already held by the forest trustees and that taken by the water board—including 200 acres in the ponds—will make a total of about 1,400 acres, which may be still further increased. This forest will be the largest area dedicated to park purposes in New England. As a writer in Garden and Forest has said: "Lynn has thus led the way in establishing the first public forest, and thus set a noble example which ought not to be without effect upon other communities."

EXPORT AND IMPORT STATISTICS.

The limited space allowed for this report necessitates the omission of the usual compilation of the tables showing the amounts of imports and exports of forest products. To give, however, in condensed form some matter of interest in this direction, the following diagrams have been prepared, showing the range in our export trade during the last twenty-five years. It will be noticed that the entire exportation of all crude and manufactured products which are derived from the forest has increased rapidly and been nearly doubled. During this time we have sent abroad, in round numbers, $720,000,000 of forest products or $28,800,000 a year; when the bulkiness of the material is considered, not a mean amount. It will also be noticed that the increase of exports is less in the wood manufactures than in the crude products; while in the range of prices per cubic foot for the last ten years it appears most striking that while the price for timber, *i. e.*, manufactured in the log or roughly sawn and hewn, has constantly risen and appreciated about 40 per cent. the price for manufactured lumber at the beginning and end of the period is almost the same.

Range of average export prices of timber and lumber for ten years.

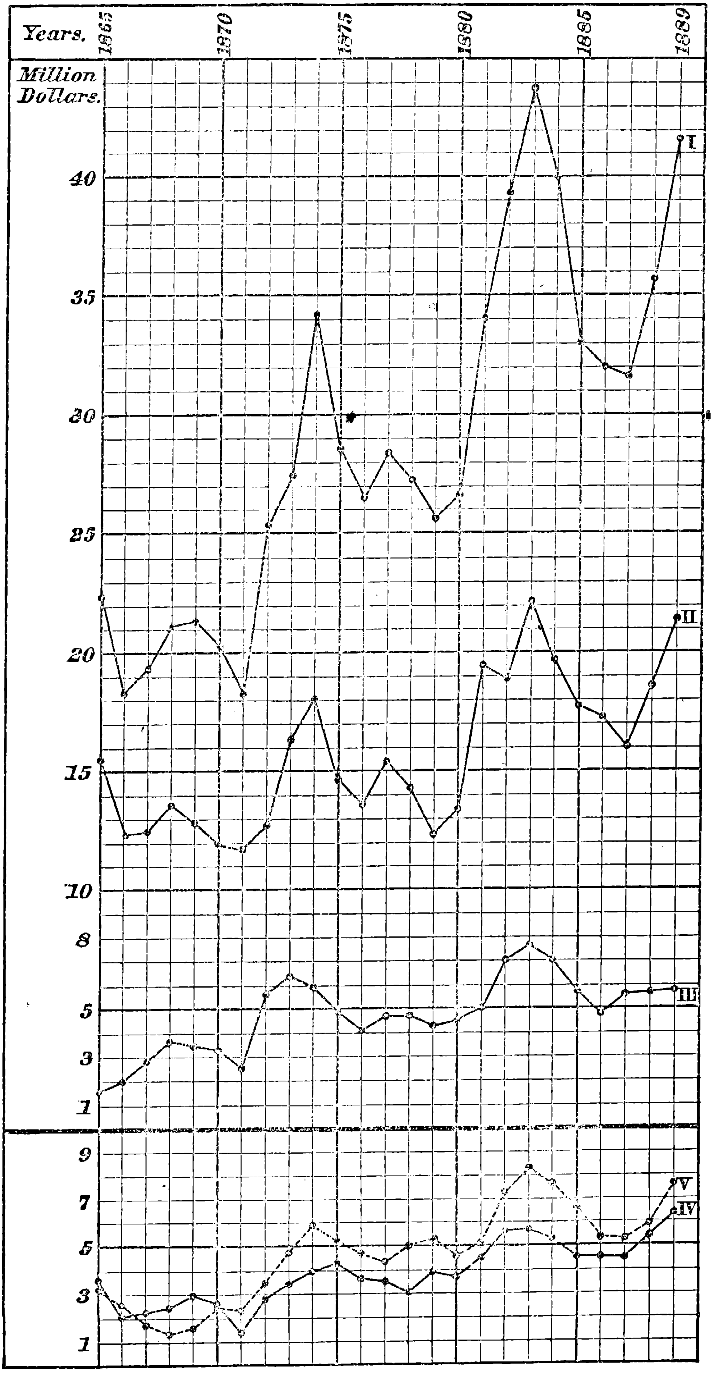
I. Prices for lumber reduced to cubic feet.
II. Prices for timber hewn and sawn, combined.
III. Prices for hewn timber.
IV. Prices for sawn timber.



Range of exports of forest products for twenty-five years from 1865 *to* 1889.

I. All forest products, crude and manufactured.
II. Lumber, timber, and partly manufactured wood products.
III. Naval stores.
IV. Wood manufactures, wholly of wood.
V. Manufactures partly of wood.

NOTE.—The summary of exports on opposite page, in addition to the materials given in the summary of the Bureau of Statistics as "Wood and its manufactures," properly includes the following products, being entirely or in their material largely derived from the forest: Naval stores, bark and tanning extracts, ashes, ginseng, sumac, together with matches, agricultural implements, carriages, cars, and musical instruments.


Years.
1865
1870
1875
1880
1885
1889
Million Dollars.
40
35
30
25
20
15
10
8
5
3
1
9
7
5
3
1
I
II
III
IV
V

PROPOSED WORK.

Without arguing what the Forestry Division of the National Government should be—namely an executive department, managing the forest lands which belong to the nation and should remain under its control, if it is simply to act as a bureau of information, it can not be difficult to conceive what the information required and what the methods of obtaining it should be for any one who will inspect my report for 1887, in which I have at length outlined a system of the science of forestry, enabling the student to form an idea of what is comprised in that science.

The division must keep in view the requirements of three classes of inquirers wanting information:

(1) The Government needs information which may serve for basis of its action in reference to its own timber lands and toward the forestry interests of the country in general. The general public naturally is desirous of the same kind of information, and both the public and the legislators need the education which will allow them to appreciate the true position of forests and forestry in the economic life of the nation.

(2) The consumers of forest products need information which will aid them in an economical and advantageous use of the same.

(3) The producers of forest products need information—if owners of natural woodlands—in regard to the best methods of utilizing these properly and managing them for reproduction; if forest planters, in regard to the best methods of starting and cultivating a timber crop.

There are two general classes of information wanted to influence and direct the action of these three classes of inquirers:

A. Information of a statistical nature, which, in the main, serves as the economic basis for action on the part of Government and individuals; and

B. Information from the field of physical and natural sciences, to serve as a basis for productive application in forest management and forest utilization.

A. Statistical information forms the only true basis for Government action with reference to forestry interests. Such action is dictated by two premises, namely:

(1) That forest supplies are apt to run short or deteriorate if left unconditionally to private discretion.

(2) That forest conditions influence climatic and cultural conditions.

The action of Government with reference to its own holdings is also influenced, besides these two considerations, by its duty as a manager of valuable property.

ad 1. The natural forest area of valuable material seems to diminish or deteriorate, (*a*) under the clearing for agricultural use; (*b*) under the action of fire and cattle; (*c*) under methods of utilization which prevent natural reforestation with valuable material.

The forest area increases (*a*) by natural recuperation of culled woodlands; (*b*) by relapsing of worn-out and abandoned fields into forest; (*c*) by forest planting.

There arises, then, a series of questions, which may be solved by statistical inquiry into the area and condition of forests, their present yield and future promise, the progress of deforestation by various agencies, and the progress of reforestation.

ad 2. Location of forest areas and their composition determine largely their value as factors of climatic and cultural conditions. Their influence is claimed in protecting soil against abrasion, in regulating water flow, in determining atmospheric and soil humidity, in diminishing deleterious action of winds, decreasing the rate of evaporation, etc.

The questions formulated under this head are partly statistical, partly belong in the field of scientific inquiry.

Statistical information is also wanted by the consumer and producer of forest products in so far as this influences their trade relations. The information supplied in answer to the questions formulated *ad* 1 will have to be further specialized and amplified for this class of inquirers.

B. Besides such information, resting upon scientific inquiry, as will aid in establishing the relation of forests to climatic and cultural conditions, there are wanted two distinct classes of information, which may be termed (1) technological, and (2) biological, more or less connected and interdependent:

(1) The consumer of forest products is mainly interested in the "dead material," the technology of woods, the possibility of their application for various purposes, the methods of prolonging their durability, substitutes, and economies in their use.

(2) The producer of forest products—the forest owner and forest planter—is concerned in the "living tree," in the life history of our timber trees, upon which to base his practices of forest management and forest planting. He wants to know what trees are adapted to his soil and climate, what trees are most profitable, what methods of starting and managing the crop promise best results.

The most pressing questions, which ought to be answered more specifically than can be done with the information on hand, are those which relate to the present conditions of our forest area, and more especially—

(1) That part which furnishes the bulk of our lumber supply and is believed to be waning—the white pine forests of the North;

(2) That part which is owned by the General Government and needs special consideration from its bearing upon water conditions in the arid regions; and

(3) The condition of supplies for special industries dependent on forest products, namely, the carriage and wagon and implement manufactures, the cooperage industry, the tanneries, the pulp manufacture, etc.

The question of general forest conditions and their change might possibly be answered through the regular staff of correspondents employed by the statistical division. The forest conditions of the timber lands belonging to the General Government might possibly be ascertained by co-operation with the agents of the United States Land Office.

The statistics of the white pine and hard-wood supplies for special industries can only be ascertained by special agents.

I repeat that Government action can rationally be based only upon carefully obtained and digested statistics; that forestry statistics are among the most difficult to gather, and that their collection is the more desirable on account of the difficulty of estimating and comparing present supplies and future requirements.

The gathering of comprehensive statistics, which alone can be of value, would necessitate an entire reorganization and such enlarge-

ment of the force of the division as may perhaps not be contemplated in spite of the desirability and urgency of this work.

Meanwhile the condition and requirements of the various industries depending upon forest products may be ascertained by special inquiries through letter and circular.

Outside of these lines of statistical inquiry there remain two most fruitful lines of work, namely, to obtain reliable information in regard to our timber trees in biological and technical direction, and to furnish by experiment a solution of the problems of timber planting on the treeless plains and arid regions.

It is a curious fact that we are by no means certain as to the qualities of our timber trees, and their consequent adaptability to various uses; still less do we know upon what conditions of soil and climate, which vary greatly with the same species, these qualities depend. Not only is the engineer interested in information on this point, but also the forest planter, for he may be led to plant a species which, while it may grow well in his locality, in the end does not develop the quality for which it was originally prized.

The systematic and comparative study of the properties of our most important timber trees, which has been begun in a small way, should therefore be continued with better facilities. The proper methods of carrying on these studies I have dealt with in former reports.

We know also very little about the life history of our timber trees, a knowledge which must be had before successful forestry can be carried on. While a certain amount of knowledge of the requirements of various trees in the nursery and for ornamental planting exists, it must not be overlooked that the behavior of the tree in the forest, and consequently its treatment by the forester, differs greatly from that in the open ground; besides, as forestry means tree culture for profit, it is very essential that the rate of growth of the various species at various ages through their whole life be known, that it be known at what age the desired quality and a profitable size may be reached, etc. The practical value of this knowledge will at once be appreciated when we look at the many black walnut plantations in the Western States which, having deceived their owners by the rapid growth of the first ten or fifteen years, are now a source of disappointment by their later slow growth; or when we see the deterioration of the soil and consequent retardation of growth, due to the planting of a thin-foliaged species by itself, when, in mixture with a shady companion, the growth would have been acceptable.

The continuation and extension of the biological studies referred to above must therefore form another direction of work, to be vigorously followed up.

There is no part of the country for which information in regard to forest planting is more needed than for the Western treeless plains and prairies. The settlers have struggled to learn what they could in this direction; they have spared no energy and braved failures; they have gathered experience, and yet, after many years of haphazard trials, there would be few who could give positive and incontrovertible evidence as to the best methods of planting and the best timbers for planting in those regions. Opinions differ as widely in the one direction as in the other.

It is therefore desirable to begin systematic experimental plantations to settle, as far as possible, these questions.

In fact, no better method of both gaining and giving information

can be devised than the practical demonstration of means and methods placed before the people right where information is most needed.

I would therefore propose to seek the co-operation of the Experiment Stations now existing in the treeless regions, and that of private individuals who can offer special facilities, in order to establish such experimental plantations upon a uniform and centrally directed plan. It would also be desirable to seek the co-operation of the authorities having charge of the military reservations in the West for a similar purpose.

From such stations it would eventually be possible to distribute plant material, as has been done successfully by the California Agricultural and Forestry Stations and elsewhere.

A desirable expenditure in the same direction would be the establishment of a national arboretum at Washington, for the purpose of collecting the timber trees that can be acclimated here. Besides many reasons of expediency, among which the educational character of such an institution in connection with this division is a potent one, the location of such an arboretum at this place recommends itself on account of the climatic conditions, which will allow to grow here in the open a greater range of arborescent plants—from the Long-leaf Pine of the South to the Spruce and Hemlock of the North and the conifers of the Pacific coast—than almost any other locality in the East.

B. E. FERNOW,
Chief of the Forestry Division.

INFLUENCE OF FORESTS ON WATER SUPPLIES.

It has been found by experience that in every department of human development nature's way of disposing of her forces is not specially favorable to progress, and that art and man's ingenuity can greatly improve upon nature, making her forces more efficiently subserve human needs.

It appears now quite certain that those countries which do not rely upon the disposition of rain-fall and snow-water as produced by the accidental and changeful, uncontrollable, and partly unknown conditions of climate, but which dispose of them in an artificial manner guided by human ingenuity, namely, by irrigation systems, produce with much greater certainty and abundance.

This once recognized, the proper distribution of the available water supplies will everywhere—not only in the arid regions—become a question of immediate interest.

Human effort in this respect can, however, not go beyond the laws of nature; it can only direct her forces and apply her laws for a given purpose. To do this, a clear understanding of the laws and forces as they are at work when left to themselves, will give us an insight as to where we can produce modifications in their working, where we may and where we may *not* expect to be successful in changing their directions.

To contribute towards such an understanding of the forces and laws which influence the natural distribution of water supplies, and

especially of the function which the forest may or may not perform in this distribution, the following pages have been written.

The water capital of the earth consists of two parts, the fixed capital and the circulating capital. The first is represented not only in the waters on the earth but also by that amount of water which remains suspended in the atmosphere, being part of the original atmospheric water-masses which, after the rest had fallen to the cooled earth, remained suspended and is never precipitated.

The circulating water capital is that part which is evaporated from water surfaces, from the soil, from vegetation, and which after having temporarily been held by the atmosphere in quantities locally varying according to the variations in temperature, is returned again to the earth by precipitation in rain, snow, and dew. There it is evaporated again, either immediately or after having percolated through the soil and been retained for a shorter or longer time before being returned to the surface, or, without such percolation, it runs through open channels to the rivers and seas, continually returning in part into the atmosphere by evaporation. Practically, then, the total amount of water capital remains constant; only one part of it—the circulating capital—changes in varying quantities its location, and is of interest to us more with reference to its local distribution and the channels by which it becomes available for human use and vegetation than with reference to its practically unchanged total quantity.

As to the amount of this circulating water capital we have no knowledge; hardly an approximate estimate of the amount circulating in any given locality is possible with our present means of measurement; for it appears that so unevenly is the precipitation distributed that two rain-gauges almost side by side will indicate varying amounts, and much of the moisture which is condensed and precipitated in dews escapes our observation or at least our measurements entirely.* Thus it occurs that while the amount of water calculated to be discharged annually by the river Rhone into the sea appears to correspond to a rain-fall of 44 inches, the records give only a precipitation over its water-shed of 27.6 inches. Even the close calculation given in my last report of the waters of the upper Elbe, according to which they drain one-fourth of the total rain-fall, calculated by the ingenious methods of Professor Studniçka, does not inspire confidence.

We must therefore enter into our discussions acknowledging ignorance of one of the most important factors, at least as to its numerical or quantitative value.

The distribution of the circulating water capital is influenced by various agencies. The main factor which sets the capital afloat is the sun, which, by its heat and the air currents caused by it, and by

*A few experiments on condensation of aqueous vapor made by L. Hampel with forest tree leaves are of interest:

	Centigrams.
Austrian pine (4 needles), condensed per day in the average	4.84
Linden (one leaf), condensed per day in the average	24.40
Oak (one leaf), condensed per day in the average	25.56
Spruce (a branchlet), condensed per day in the average	9.80

The linden, of which one leaf condensed 24.40 centigrams of dew, had 1,763 leaves. It would, therefore, if all leaves had done the same, which is to be sure not the case, have condensed 430 grams.

On grass the amount of dew per year was found by G. Dines to be 27 millimeters, *i. e.*, if collected an amount corresponding to 27 millimeters height of water would have resulted.

the rotation of the earth, produces the evaporation which fills the atmosphere with vapor. Anything, therefore, that influences the intensity of insolation, the action of the sun, or obstructs the passage of winds, must influence the local distribution of the water capital. The great cosmic influences which produce the variability of all climatic conditions, and therefore also of the circulating water capital, are the position of the earth's axis to the sun by which the angle and therefore the heat value of the sun's rays vary in different parts of the earth and at different times of the year; the distribution of land and water areas, which produces a difference of insolation because the water has less heat capacity than the land, and which also influences the direction of air and sea currents; the configuration of the earth, by which the density of the atmosphere is made unequal, and in consequence of which differences of insolation and of air temperature are induced. Thus we have not only climatic zones, but also continental climates and mountain climates in opposition to coast climates and plains or valley climates.

While this classification of cosmic climates satisfies the climatologist, there are many local climates to be found within the range of the cosmic, and the local climatic conditions are those which affect human life and human occupations most sensibly.

The same causes, different only in degree, which modify the cosmic climates, making a classification of the same possible, effect further modifications and give rise to local climates; these causes are different in the degree of insolation, obstruction to air currents, presence of water surfaces, or moisture-laden air-strata.

Among the factors which thus modify the cosmic climate and help to produce a local climate differing from other local climates, the soil-cover and especially the presence of forest areas is claimed as one that, under certain conditions, is potent; and this factor being under the control of human agency more than any other possible modifier of climate, must therefore be of greatest interest to us.

In the discussions which have prevailed hitherto, it has always been overlooked that the idea of what constitutes a forest is not only an exceedingly variable one, but that without a definite understanding of what constitutes the forest we cannot discuss its influence. It is clear, from what has been stated so far, that the influence of the forest, if any, will be due mainly to its action as a cover protecting soil and air against insolation and against winds. That the nature of a cover, its density, thickness, and its proper position has everything to do with the amount of protection it affords everybody will admit. A mosquito net is a cover, so is a linen sheet or a woolen blanket, yet the protection they afford is different in degree and may become practically none. It will also be conceded that it makes a great difference whether the cover be placed before or behind the wind. Just so with the influence of the forest; it makes all the difference whether we have to do with a deciduous or coniferous, a dense or an open, a young low or an old high growth, and what position it occupies with reference to other climatic elements, especially to prevailing winds and water surfaces. In the following discussion, when the word forest is used, unless differently stated, a dense growth of timber is meant.

Hitherto the discussion of forest influences has relied mainly upon general observations and the recital of experiences from which such influences are inferred. From the complication of causes which produce climatic conditions, it has been always difficult to prove,

when changes of these conditions in a given region were observed, that they were permanent and not due merely to the general periodic variations which have been noted in all climates of the earth, or that they were due to a change of forest conditions and to no other causes; hence some climatologists have thought proper to deny such influences entirely. On the other hand there are as trustworthy and careful observers who maintain the existence of such influences; but only of late has the question been removed from the battle-field of opinions, scientific and unscientific, to the field of experiment and scientific research, and from the field of mere speculation to that of exact deduction. But the crop of incontrovertible facts is still scanty and further cultivation will be necessary to gather a fuller harvest and then to set clear the many complicated questions connected with this inquiry.

Yet the question of the relation of forest cover to water supplies has become of such immediate concern, in our endeavor to develop the arid or subarid regions of the West with the aid of irrigation, while forest destruction, by fire more than by the ax, has bared the hills and mountains of their forest cover and their forest floor, that it seems timely to rehearse what we do actually know of this relation.

The question of forest influence on water supplies can be considered under three heads, namely: Influence upon precipitation or distribution of atmospheric water; influence upon conservation of available water supplies; influence upon the distribution or "run-off" of these supplies.

INFLUENCE UPON PRECIPITATION.

Whether forest areas are or are not capable of appreciably increasing precipitation within their limits or on neighboring ground is still a matter of dispute, and the complexity of the elements which must enter into the discussion has so far baffled solution based upon definite and strictly scientific observation. Yet new evidence is accumulating all the time, which *apparently* shows that under certain conditions forest areas obtain larger precipitations than open grounds, that is, they increase at least the amount of precipitation over their own immediate and near-lying areas. Of the prominent meteorologists who believe in such an influence is the well-known Russian, Dr. A. Woeikoff, from an unpublished translation of whose latest publication, "Climates of the Earth," written in the Russian language, I am enabled, through the courtesy of Professor Cleveland Abbe, to quote:

The problem of the influence of forests on the amount of precipitation eluded for a long time an accurate solution, not only because the effect is extremely variable both from year to year and from place to place at short distance, but also on account of the modifying influence of local conditions. It was therefore necessary to select the conditions for such observations, so as to render the results mutually comparable. At the present time the best observations made are those made in the neighborhood of Nancy, France. The instruments and their disposition were identical at the different stations. The situation of the stations was as follows:*

Station A (Cinq-Franchées), 8 kilometers west of Nancy, *in the midst of extensive forests* (La Haye), *growing on a plateau of lower oölite formation. Height above the sea-level* 380 *meters.* The rain-gauge is placed in an open glade of several hectares of area.

*The information is derived from Mathieu's *Relevé des Observations de Météorologie agricole et forestière*, in the *Atlas Météorologique de l'Observatoire de Paris*, 1887.

Station B (Bellefontaine), 6 kilometers northwest of Nancy; 240 *meters above the level of the sea*, in a valley running from southeast to northwest, on the margin of the La Haye forests. The rain-gauge is placed outside the woods, in a nursery.

Station C (Amance), 10 kilometers northeast of Nancy, near the summit of a hill of the lower oölite formation, 380 *meters above the level of the sea. The surrounding country while not entirely destitute of woods is chiefly occupied by fields.* Thus, at least for the Stations A and C, *both the elevation above the sea and the geological formation are the same.* Besides, the surroundings of Nancy are not mountainous and consist mostly of low plateaus more or less washed out by the water. Such localities are also frequently found in European Russia. A is a forest station, C a field station; B is on the verge of the forest and at a lower level. The following table gives the amount of rain-fall, in centimeters, for the seven years 1867, 1868, and 1872, 1873, 1874, 1875, and 1876:

Time of observations.	Station A (forest glade), 380 meters.	Station B (forest verge), 240 meters.	Station C (field), 380 meters.
	Cm.	*Cm.*	*Cm.*
February to April	15.9	16.2	14.9
May to July	18.9	17.1	16.6
August to October	20.7	17.2	15.7
November to January	21.2	18.8	17.7
Year	76.7	69.3	64.9

Comparing Stations A and C, we see that much more water falls on the forest glade than in the open fields, and that the difference is least in early spring.

Of the eighty-four months for which I have the data, sixty-three give more water at A than at C; two, the same quantity; and only nineteen more at C than at A. It further appears from an examination of the table for the separate months, that the greater quantity at A is not due to more copious and frequent heavy showers, giving a great amount of water on a small area. I found only three months, July, 1872, and July and August, 1875, in which the great difference between A and C would point to such showers as cause. Including these months, we have:

A in July 7.2, in August 6.2.
C in July 6.8, in August 4.0.

Excluding the same we find:

A in July 7.0, in August 4.8.
C in July 6.7, in August 4.0.

And in the annual mean,

A 75.1, C 64.8.

The Station B occupies a middle position between A and C, which again shows that the difference between A and C is due to the influence of the forest vegetation.*

The fact of the increase of precipitation by forests requires an explanation. I shall first consider climatic conditions as they are found in central and northern Europe, beginning with the conditions prevailing in winter. It would appear as if in winter the difference in the amount of rain-fall within and without the woods can not be great, as the absolute amount of vapor is small and the difference between the relative humidity within and without the woods is insignificant. This is however not the case, for two reasons. First, the clouds float in winter at a lower level than in summer; hence the mechanical resistance presented by the woods is more effective in winter, as it can more easily reach the strata of the atmosphere in which the clouds are moving. This resistance causes the air to rise and thus favor the formation of precipitation. Secondly, in winter the prevailing winds are generally charged with moisture and precipitation is of longer duration, so that the above-named causes act for a longer time.

In the spring and the beginning of winter the woods contribute more or less to the increase of precipitation. At this time of the year evaporation is very actively going on outside of the woods on the surface of the meadows and fields. During the winter the soil has been well stocked with moisture, which is now evaporated by the action of the processes of vegetable life and the direct access of the sun. *It is probable that during this period both the possible and the actual evaporation are*

* See also Fautrat' spaper "*Influence des bois feuillus et résineux*" Comptes Rendus, vol. 85, p. 340.

greater without than within the forest, evaporation being here understood as the sum of all water evaporated both by the soil and the plants from a given area.

In the middle of summer or toward the beginning of autumn the soil outside the woods begins partly to dry up and can not any more yield as much moisture for the evaporation of the plants as in the beginning of summer; on the other hand the vegetable processes following upon the blooming (the ripening of the seeds) require less moisture. But in the leaved woods evaporation continues in full force to the end of the summer, and in coniferous woods the evaporating surface remains approximately the same in the course of the whole year; at the same time the moisture preserved in the soil through shade and protection from wind continues to furnish sufficient material for evaporation. Consequently, just at the time when meadows and fields begin to evaporate less, it goes on as before in the forests. This gives rise to a great difference between the amount of moisture contained in the air within and near the woods, and outside of the woods in open places. Moist air more easily reaches the point of saturation and condensation than dry air.

The following point is also to be noticed. Forests, especially pine woods, must condense a great deal of moisture in winter when air nearly saturated with vapor passes over them; this gives rise to copious formations of hoar frost, which will fall to the ground and increase the mass of snow in the woods. This phenomenon has never been accurately observed and measured; but careful observation will convince anybody that wherever the temperature for several consecutive months remains below zero (as is the case in northern and eastern Europe), a considerable amount of hoar-frost is in this way collected, since the air is highly charged with moisture, and besides, the average force of the wind is greater in winter than in any other season.

In hot and moist climates where the absolute amount of vapor in the air is great (for instance in many tropical countries), the enormous surface presented by the leaves of forest trees condenses a great quantity of water on every clear and calm night, so that this water can not be retained on the leaves and falls to the ground; the observer gets the impression of a heavy rain-fall.* Thus, a certain part of the moisture evaporated by the leaves during the day returns at night, and the dew is so copious as to moisten the soil under the trees.

The observations made in the neighborhood of Nancy are at present the only proof that not only above trees but also over forest glades the precipitation is greater than in the midst of extensive fields; if, however, this phenomenon has once been clearly proved, it can hardly be doubted that it recurs at other places. In order to prove that influence of forests does not exist or that forests tend to decrease the amount of precipitation, it would be necessary to present observations made under conditions which would render them as easily comparable as those described by me above.

The author then proceeds to discuss the influence of forest areas in tropical and subtropical countries, which he finds still more marked. Conditions in India are exhibited in the following table:

Influence of forest areas on rain-fall in India.

Name of place.	Distance from the sea.	Mean temperature.				Extreme maxima.*	Relative humidity.				Precipitation.			
		April.	May.	June.	July.		April.	May.	June.	July.	April.	May.	June.	July.
Woodless country:	*Kms.*										*Cms.*	*Cms.*	*Cms.*	*Cms.*
Lucknow	847	30.1	33.3	33.1	30.4	45.8	30	36	54	74	0.5	1.8	13.3	39.4
Benares	590	30.2	33.2	32.8	29.7	45.0	41	60	81	82	0.5	1.3	12.9	32.4
Patna	445	30.3	31.4	31.4	29.2	44.6	....	....	....	....	1.0	2.5	16.9	27.8
Barhampur	270	29.6	30.1	29.2	28.7	44.1	52	60	75	79	5.6	10.1	24.2	25.8
Wooded country:														
Goalpara	427	25.2	25.9	26.9	27.7	35.1	66	77	85	84	14.8	33.6	64.3	50.0
Sibsagar	555	23.5	25.3	28.2	28.5	35.6	81	82	83	83	25.9	30.8	39.5	40.6

*Mean of two years.

A glance at this table will show *that the presence of woods has a far greater influence in mitigating the temperature during the hot and dry months of April and May than the proximity of the sea. The same is true of the relative humidity,*

* This was specially pointed out by the celebrated Boussingault, who observed it in South America.

especially at Sibsagar, *i. e.*, *in the middle of the forests. Most striking is the effect of the presence of woods in the diminution of the extreme maxima. The greater or less proximity of the sea has but little effect, but as soon as we reach the wooded region the extreme maximum falls* 9 *degrees.* Thus in 1875 the maximum thermometer did not rise above 35.3 degrees at Goalpara, while at Lucknow there was not a single day from March 14 to June 22 on which a higher temperature had not been observed. The great humidity of the air even during the hot and dry months of April and May is the cause why, in the forests, the rains begin early in March and gradually increase in intensity until June or July, while in the woodless plains of the Ganges the amount of rain-fall suddenly increases from May to June or from June to July.*

It is also noteworthy that *the distance between Benares and Goalpara is* 760 *kilometers, the latitude is nearly the same*, the intervening country is level, the distance to the sea is in both cases considerable; and yet the mean temperature of May differs 7.4 degrees Fahrenheit, or about 1 degree centigrade per 100 kilometers. *At no place on the earth*, for which we have observations, has *such a difference of temperatures ever been observed under similar circumstances.* It is, however, to be observed that we have but few good observations in the tropics and in latitude below 30 degrees, especially in the interior of continents. It may be expected that in South America, where in nearly the same latitude extensive prairies (Llanos) and dense virgin forests can be found, similar differences of temperature may be observed in the same months (April and May).

At the present time there are in the basin of the Amazon four stations where observations are made; this river-basin is the most extensive forest region on the earth. The middle and upper portion of the course of the Amazon is over 1,000 kilometers distant from the Atlantic Ocean, while it is separated by mountains from the Pacific. Were it not for the forests we ought to expect, at this distance from the sea and so near the equator, very high temperatures and great dryness. The following table shows the results of the observations:

Difference of temperature of four stations in the basin of the Amazon.

Name of station.	Height above sea.	South latitude.	Distance from Atlantic.	Temperature.			Relative humidity for the year.
				Annual mean.	Mean of hottest month.	Extreme maxima.	
	Meters.	*Degrees.*	*Kilom.*				
Para*	....	1¼	100	27.0	27.7	....	....
Manaos	37	3	1,150	*26.1	27.0	*35.7	*80
Iquitos	95	3¼	2,100	24.8	25.7	32.4	83
Pernambuco†	3¼	8	0	25.7	27.1	31.7	72
San Antonio on Madeira River	....	9	1,750	26.0	27.0	....	....

* Ten months, from October to July.
† Pernambuco does not belong to the Amazon basin; its means are only given for comparison with those of San Antonio. The shore-line near Pernambuco is wooded, but a certain distance around the city the forests are cut down to give way to fields and sugar-cane plantations.

Thus, owing to the vast primeval forests on the Upper Amazon and its tributaries, the temperature of the hottest month and the extreme maximum are not greater than on the sea-coast; and the extreme maximum is far from reaching the values sometimes observed in middle latitudes. It is also to be observed that there are few regions on the earth where the "Trades" blow with such violence as on the coasts of northern Brazil; Pernambuco is therefore subject not only to the influence of the sea but also to that of a furious trade-wind. Along the lower course of the Amazon the "Trade" also blows with great force; but as soon as we turn into the side valley of one of the tributaries running in a southerly and northerly direction calm weather is found to prevail. The height and density of the forest arrests the wind. There can be no doubt that the vast tracts of forest land on the Amazon, contributing to maintain the moisture of the air and weaken its motion, increase

* As regards the great difference of climate between Assam and the plains of the Ganges, the Indian meteorologist, Blanford, informs me by letter that he attributes this difference, *i. e.*, the greater moisture of the air, the lower temperature from April to June, and the early beginning of the rains observed at Assam, to the vast dense forests covering the country.

the amount of water-fall. At Iquitos 284 centimeters fall in the course of the year. It must be remembered that Iquitos lies in a plain 2,100 kilometers from the ocean and 350 from the mountains; nowhere on the earth is the rain-fall so great under similar circumstances.

Without further discussing the influence of the forest upon quantity and distribution of rain-fall, we may say that many observations and the philosophy of meteorological forces lend countenance to the following statements:

(1) During the time of vegetation large quantities of vapor are transpired and evaporated by a forest, by which the absolute humidity of the air above the forest is increased; and since, on account of the cooler temperature which prevails over and within a forest, the relative humidity is also greater, the tendency to condensation is increased.

(2) This moister and cooler air stratum communicated to the neighboring locality must increase the dew, at least, over the neighboring field.

(3) This relatively moister air stratum, carried away by air currents, has the tendency to induce precipitation at such places, especially where the additional influence favorable to precipitation—namely, increased altitude—exists; therefore,

(4) While the forest may not *everywhere* increase precipitation over its own area, yet a large system of forests over an extensive area will influence the quantity of precipitation over and within this area.

(5) It must never be overlooked that there are certain rain conditions prevailing in climatic zones (rainy or rain-poor localities, with periodical, seasonal, or irregular rains) which are due to cosmic influences and can not be altered, but may be locally modified by forest cover. Hence, experiences in one climatic zone can not be utilized for deductions in another.

DISPOSAL OF WATER SUPPLIES.

Given a certain amount of precipitation in rain or snow over a certain area, the disposal of the water after it has fallen, and the influence of the forest-cover on its disposal, require our attention. For the sake of convenience we can divide the elements which need consideration in this discussion into elements of dissipation, elements of conservation, elements of distribution.

The difference in effect between the first two classes of elements will give us an idea of the amount of available water supply or run-off resulting from precipitation; while the third class bears upon the methods of distributing the available water supply.

ELEMENTS OF DISSIPATION.

Elements of dissipation are those which diminish the available water supplies; they are represented in the quantity of water which is prevented by interception from reaching the ground, in the quantity dissipated by evaporation, in the quantity used by plants in their growth, and in transpiration during the process of growing.

Interception.—The amount of rain-fall and snow which is prevented by a forest growth from reaching the soil varies considerably according to the nature of the precipitation and to the kind of trees which form the forest as well as the density and age of the growth.

A light drizzling rain of short duration may be almost entirely intercepted by the foliage and at once returned to the atmosphere by evaporation; if, however, the rain continues, although fine, the water will run off at last from the foliage and along the trunks.* And this amount, of which the rain-gauge takes no account, represents, according to measurements of the Austrian stations, from 8 to 14 per cent., thus reducing considerably the loss to the soil.

While the careful measurements at the Swiss stations in a twelve years' average show the interception in a larch forest as 15 per cent., in a spruce forest 23 per cent., in a beech growth 10 per cent., the figures for the Prussian stations are for beech growth 24 per cent., for spruce at various stations 22 per cent., 27 per cent., and 34 per cent., respectively. Altogether, for the rain-fall conditions of the countries cited, a dense forest growth will, on the average, intercept 23 per cent. of the precipitation; but if allowance be made for the water running down the trunks, this loss is reduced to not more than 12 per cent.

The amount of interception in the open growths which characterize many of our Western forest areas would be considerably smaller, especially as the rains usually fall with great force, and much of the precipitation is in the form of snow. Although branches and foliage catch a goodly amount of this the winds usually shake it down, and consequently but very little snow is lost to the ground by interception of the foliage.

There is also a certain amount of water intercepted by the soil-cover and held back by the soil itself, which must be saturated before any of it can run off or drain away. This amount, which is eventually dissipated by evaporation and transpiration, depends, of course, upon the nature of the soil and its cover, especially upon their capacity to absorb and retain water.

This retentive power is called the maximum water capacity of the soil, and depends largely upon the structure and more or less compact stratification of the material. The least retentive soil is a coarse sand followed by finer sands, loams, clays, marls, and organic matter; that is to say, humous earth or vegetable litter will retain the most water. The amount of such retention, varying somewhat with the temperature, as shown in the analyses of Professor Hilgard and others, is from 1.64 per cent. of its own weight in a "second class" Florida sand soil to 23 per cent. and more in a peat soil; a pure clay rarely exceeds 12 per cent., while calcareous clay soils rise to 15 and 20 per cent.

Different from this hygroscopic water, known as "moisture co-efficient," which represents the amounts of water permanently absorbed by the soil in its natural condition, is the amount which it may hold temporarily, liable to be drained off or evaporated. According to Ebermayer, these amounts may vary from 3 to 88 per cent. According to Dr. Raman's investigations, the water capacity of sand soils of fine and medium fine texture may amount to from 3 to 4 per cent. of their own weight, or 4 to 5 per cent. of their volume in the upper strata, and 5 to 6 per cent. in the lower strata. Impermeable soil strata (loam and very fine sand) allow, when a superficial run-off is possible, only a passing and inferior retention of water after precipitation; being capable in spring-time of holding no more than 10 or 12 per

---

*The maximum rain-fall observed in Germany is 4 inches in twenty-four hours and 2 inches in one hour. In Switzerland there has been recorded a rain-fall of 18 inches in twenty-four hours and 2¼ inches in three-quarters of an hour. This would equal 5,000 gallons per acre. Of such falls the foliage will retain only an inappreciable amount. Intensity of rain-fall in the United States becomes clear from a few records: Paterson, N. J., 1½ inches in eight minutes; Sandy Spring, Md., 5 inches in 2½ hours; Clear Creek, Nebr., 4.50 inches in one hour twenty-seven minutes; Castroville, Tex., 5.80 inches in twenty-four hours; Ellsworth, N. C., 13 inches, of which 9 inches in three and one-half hours; and rain-falls from 1½ to 4 inches per twenty-four hours are quite frequently reported in almost every month, especially in the Western States, where the rain-fall is often quite explosive.

cent. of their weight, while a stratum of sand of medium grain 20 to 25 feet deep would, it was calculated, be capable of taking up and holding the entire annual precipitation of 24 inches.

As to the distribution of water in the soil, it is found that the upper humous strata contain the highest amounts, the following deeper strata the least; the water capacity then increases downwards, and at last remains stationary to a considerable depth. The capillarity of the sand soils investigated was not capable of raising the ground water higher than 1½ feet, so that the upper strata of the soil which was within reach of ground water did not show in reality greater amounts of water than the soil which had no ground water to fall back upon.

The water capacity of litter, which Wollny investigated, depends on its nature and, of course, its thickness to a certain degree, and is quite considerable, much greater than that of soils.

The water capacity of various litters was found to be as follows in volume per cent.:

Depth of litter.	Oak leaves.	Beech leaves.	Spruce litter.	Pine litter.	Moss.	Calcareous sand soil.
When 2 inches deep	50.77	......	38.93	......	19.82	......
When 12 inches deep	45.42	39.78	41.65	36.28	......	24.93

No soil cover was found so variable in water contents as moss, while litter would hold two or three times as much water as moss and twice as much as the soil.

The variation of water capacity at different depths appears from the following figures:

Depth of litter.	Oak leaves.	Spruce leaves.
Two inches	50.77	38.98
Four inches	52.99	40.76
Eight inches	53.09	41.03
Twelve inches	45.42	41.65

That is to say, the increase in water capacity ceases with about 8-inch depth.

Altogether an appreciable amount of the precipitation does not run off or drain through the forest cover but is retained by it; yet while this is apparently a loss, we shall see further on that this moisture retained in the upper strata fulfills an important office in checking a much greater loss due to evaporation, and thus becomes an element of conservation.

Evaporation.—The loss by evaporation after the water has reached the ground depends in the first place upon the amount of direct insolation of the soil, and hence its temperature, which again influences the temperature of the air. The nature of the soil cover, the relative amount of moisture in the atmosphere, and the circulation of the air are also factors determining the rate of evaporation. The importance of this element of dissipation may be learned from the experiments of Prof. T. Russell, jr., of the U. S. Signal Service, made in 1888. We learn from these that the evaporation on the Western plains and plateaus may, during the year, amount to from 50 to 80 inches, nay, in spots, 100 inches, while the rain-fall (diminishing in reverse ratio) over this area is from 30 to 12 inches and less.

Thus in Denver, where the maximum annual precipitation may reach 20 inches, the evaporation during one year was 69 inches.

This deficiency of 49 inches naturally must be supplied by waters coming from the mountains, where the precipitation is large and the evaporation low (on Pike's Peak alone, there may be 45.6 — 26.8 = 18.8 inches to spare).

If the loss by evaporation from an open field be compared with that of a forest-covered ground, it will, as a matter of course, be found to be less in the latter case, for the shade not only reduces the influence of the sun upon the soil, but also keeps the air under its cover relatively moister, therefore less capable of absorbing moisture from the soil by evaporation. In addition, the circulation of the air is impeded between the trunks, and this influence upon available water supply, *the wind-breaking power of the forest*, must be considered as among the most important factors of water preservation. Especially is this the case on the Western plains and on those Western mountain ranges bearing only a scattered tree growth and where, therefore, the influence of shade is but nominal.

The evaporation under the influence of the wind is dependent not only on the temperature and dryness of the same, but also on its velocity, which being impeded, the rate of evaporation is reduced.

Interesting experiments for the purpose of ascertaining the changes in the rate of evaporation effected by the velocity of the wind were made by Prof. T. Russell, jr., of the Signal Service, in 1887. The result of these experiments (made with Piche's hygrometers whirled around on an arm 28 feet in length, the results of which were compared with those from a tin dish containing 40 cubic centimeters of water exposed under shelter) show, that with the temperature of the air at 84 degrees and a relative humidity of 50 per cent., evaporation at 5 miles an hour was 2.2 times greater than in a calm; at 10 miles, 3.8; at 15 miles, 4.9; at 20 miles, 5.7; at 25 miles, 6.1, and at 30 miles the wind would evaporate 6.3 times as much water as a calm atmosphere of the same temperature and humidity.

Now, if it is considered that the average velocity of the winds which constantly sweep the Western subarid and arid plains is from 10 to 15 miles, not rarely attaining a maximum of 50 and more miles, the cause of the aridity is not far to seek and the function of the timber-belt or even simple wind-break can be readily appreciated.

What the possibilities of evaporation from hot and dry winds may be, can be learned from statements regarding the "Foehn," which is the hot wind of Switzerland, corresponding to the "chinook" of our Western country.

The change in temperature from the normal, experienced under the influence of the Foehn has been noted as from 28° to 31° Fahr., and a reduction of relative humidity of 58 per cent. A Foehn of twelve hours' duration has been known to "eat up" entirely a snow cover of 2½ feet deep.

In Denver a chinook has been known to induce a rise in temperature of 57° Fahr. in twenty-four hours (of which 36° in five minutes) while the relative humidity sank from 100 to 21 per cent.

The degree of forest influence upon rate of evaporation by breaking the force of winds is dependent upon the extent and density of the forest, and especially on the height of the trees. For according to an elementary law of mechanics the influence which breaks the force of the wind is felt at a considerable elevation above the trees. This can be practically demonstrated by passing along a timber plantation on the wind-swept plains. Even a thin stand of young trees not higher than five feet will absolutely calm the air within a

considerable distance and height beyond the shelter. Unfortunately no accurate experimental data concerning this influence are at hand. According to Becquerel, a simple hedge 6 feet in height will give protection for a distance of 70 feet; and according to Hardy, a belt of trees every 300 feet will defend vegetation almost entirely against the action of the wind. Another authority finds for every foot in height one rod in distance protected.

This division has lately begun a canvass to ascertain the actual experience in regard to the value of wind-breaks on the prairies and plains. This canvass is not completed as yet, but to show what the drift of this experience is, we give an extract from the letter of one farmer in Illinois:

> My experience is, that now in cold and stormy winters wheat protected by timber belts yields full crops, while fields not protected yield only one-third of a crop. Twenty-five or thirty years ago we never had any wheat killed by winter frost, and every year a full crop of peaches, which is now very rare. At that time we had plenty of timber around our fields and orchards, now cleared away.

It may not be necessary to state that the damage done to crops by the cold dry winter winds is mainly due to rapid evaporation, and that plants are liable to suffer as much by winter drought as by summer drought.

This is certain, that since summer and winter drought, *i. e.*, rapid evaporation, due to the continuous dry winds. is the bane of the farmer on the plains, rationally disposed timber belts alone will do much to increase available water supply by reducing evaporation.

Various experiments comparing the rate of evaporation within and without a forest are recorded in the following table, which refers to evaporation from a water surface in the open field on the one hand and within the shelter of the forest on the other. It is shown that under ordinary circumstances evaporation may under forest cover be decreased from two to three times.

Evaporation of a water-surface from April to October, expressed in centimeters.

	Without the forest.	Within the forest.	Ratio.
Eastern France ......(2) ..	41.2	13.2	312 to 100
Alsatian Mountains....(3) ..	33.5	15.9	211 to 100
Bavaria ....(4) ..	37.7	15.8	239 to 100
Brandenburg..........(5) ..	39.9	16.3	245 to 100
Silesian Mountains ....(6) ..	26.7	10.6	250 to 100
Eastern Prussia ....(7) ..	25.2	12.0	210 to 100

References to table: (2) Station Belle-fontaine, (3) Station Melkerei, (4) Six Stations, (5) Station Eberswalde, (6) Station Carlsberg, (7) Stations Fritzen and Kurwien.

An experiment made in Bavaria in which soil saturated with water was used, showed the values in centimeters of evaporation for seven months—from April to October—to be as follows:

Without the forest....................................40.8
Within the forest:
  Pine woods..15.9
  Deciduous trees..................................... 6.2

That is to say, evaporation progressed six and one-half times as fast in the open field as in the deciduous woods during the warm months.

The stations of Prussia allow the following average for evaporation; the amount evaporated in the open fallow field being called 100:

	Evaporated.	Retained more than in open fallow field.
	Per cent.	*Per cent.*
Under beech growth	40.4	59.6
Under spruce growth	45.3	54.7
Under pine growth	41.8	58.2
From cultivated field	90.3	9.7

A balance calculation of the amounts of precipitation and the amounts lost by evaporation for sixteen stations at varying elevations shows that with increasing altitude the surplus of water remaining for the soil increases, the mountain forest decreasing evaporation to its minimum of 9 to 13 per cent., and leaving from 87 to 91 per cent. to penetrate the soil.

Stations.	Altitude.	Surplus of precipitation over evaporation.		Of precipitation evaporated.	
		In the open.	In the forest.	In the open.	In the forest
	M.	*Mm.*	*Mm.*	*Per ct.*	*Per ct.*
Schoo	3	322.5	343.6	55	28
Fritzen	30	357.5	322.5	40	28
Hadersleben	34	495.8	481.4	35	20
Eberswalde	42	142.1	237.5	73	44
Lintzel	95	174.6	180.6	70	67
Average for the region	0–100	305.3	313.1	55	37
Kurwien	124	243.1	365.7	44	26
Marienthal	143	184.9	254.7	68	37
Hagenau	145	436.1	434.3	46	26
Average for the region	100–200	322.4	351.6	53	30
Neumath	340	328.5	510.9	60	23
Friedrichsrode	353	291.0	365.8	57	26
Average for the region	300–400	309.9	448.3	58	25
Lahnhof	602	850	685.2	24	15
Hollerath	612	717.5	490.2	26	21
Schmiedefeld	680	1,468.2	1,114.3	13	7
Carlsberg	690	718.8	839.1	27	10
Average for the region	600–700	938.7	782.2	22	13
Sonnenberg	774	1,195.4	1,083.8	15	9
Melkerei	930	1,142.1	1,196.8	19	11

The reason for this influence of the forest, as has been stated, is due not only to the impeded air circulation, but also to the temperature and moisture conditions of the forest soil and forest air.

From the following table appear the differences of soil temperature (centigrade) in the forest, the minus sign denoting the lower temperatures in the forest, the plus sign the higher temperatures:

Differences of temperature of the soil inside and outside of a forest.

	February-April.		May-July.		August-October.		November-January.		Year.	
	Surface.	0.9 m.	Surface.	0.9 m.	Surface.	0.9 m.	Surface.	0.9 m.	Surface.	0.9 m.
Alsatian Mountains (1)	−1.0	+0.5	−7.8	−2.8	−5.7	−3.2	+0.3	−0.7	−3.5	−1.5
Bavaria (1)	−1.8	−0.8	−4.5	−3.9	−2.6	−3.0	0	−0.1	−2.2	−2.2
Bavaria (2)	−1.3	−0.6	−4.6	−4.1	−2.6	−3.0	+0.3	−0.1	−2.1	−2.0
Eastern Prussia	−1.8	0	−4.4	−3.6	−2.3	−2.2	+1.3	+0.9	−1.6	−1.2

(1) Same stations as for preceding table on page 308.
(2) Same stations with the addition of Duschberg, Johanneskrenz, and Altenfurth.

It appears that in winter it may occur that the soil is even warmer in the forest, especially in regions which, like eastern Prussia, have cold winters and where the ground is covered with snow for several months.

The mitigating influence on the soil temperature appears still more clearly when the maximum and minimum temperatures for the year or the range of temperature is compared.

	Range of temperature.	
	Without the forest.	Within the forest.
	Degrees.	*Degrees.*
Bavaria	39.5	29.5
Alsatian Mountains	35	21
Eastern Prussia	41.8	26.7

For the air temperatures the differences are much smaller, yet in general the summer temperatures are lower and the winter temperatures are higher in the forest, and this influence seems greater in the warm climate of Italy than in the colder climate of Prussia. In the following table the maximum, minimum, and mean temperatures within forest stations are noted—the plus sign denoting higher the minus sign lower temperatures than those observed in the field stations.

	February-April.			May-July.			August-October.			November-January.			Year.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Central Italy (1)	....	....	....	−4.1	+1.6	−1.2	−3.6	+1.1	−1.3	....	....	....	....	....	
Eastern France (2)	−0.8	+0.8	0	−3.2	+1.2	−1.0	−2.6	+1.3	−0.6	−0.9	+0.6	−0.1	−1.9	+1.0	−0.4
Alsatian Mountains (3)	−1.1	+1.9	+0.4	−2.5	+1.9	−0.3	−1.9	+2.4	−0.2	+0.9	+1.7	+1.3	−1.2	+2.0	+0.4
Bavaria (4)	−0.5	+0.2	−0.3	−2.2	+1.1	−0.9	−3.2	+1.6	−0.8	0	+1.2	+0.6	−1.5	+1.0	−0.3
Eastern Prussia (5)	−0.7	+0.1	−0.3	−1.4	+0.5	−0.4	−1.6	+0.2	−0.7	−0.3	−0.2	−0.2	−1.0	+0.2	−0.4

(1) Station Vallambrosa, Tuscany. (2) Station Bellefontaine near Nancy.
(3) Station Melkerei, in the Vosges Mountains. (4) Stations Seeshaupt and Rohrbrunn.
(5) Stations Fritzen and Kurwien.

The greater humidity of the atmosphere under forest cover, *i. e.*, in shade, tends also to reduce evaporation. The temperature, especially during the warm months, being considerably lower in the forest interior, the air receives less moisture in proportion from the soil and lower vegetation. A cubic foot of forest air, then, contains in the average less moisture than a cubic foot of air over a cultivated field under otherwise same conditions.

While thus the absolute amount of moisture in the forest air is really less, the relative humidity is greater; that is, the air of the forest being of lower tempera-

ture is nearer the state of saturation. The state of affairs is exhibited in the following tabulated observations:

Influence of forests, especially in summer, on the moisture of the air, expressed in percentages of the state of saturation.

[Relative humidity within and without the forest.]

	February–April.		May–July.		August–October.		November–January.		Year.	
	With-out.	With-in.	With-out.	With-in.	With-out.	With-in.	With-out.	With-in.	With-out.	With-in.
Alsatian Mountains (1)	80	85	68	75	73	84	85	89	77	84
Bavaria (2)	80	84	70	80	78	85	87	90	79	85
Eastern Prussia (3)	84	85	64	68	76	81	90	92	78	82

(1) Melkerei. (2) Six stations. (3) Fritzen and Kurwien.

The difference of temperature of the soil, and therefore also of the air, is dependent as well upon the degree of shade exerted by the forest cover as upon the nature of the soil cover. The influence of the latter has been carefully investigated by Wollny. In the following table is noted the range of temperature during the day of various soil-covers, from which it appears that the naked soil cools off during the night much more and heats up much more during the day than the various soil-covers, of which pine litter shows the next greatest range to naked soil.

	Soil, calcareous sand.	Pine litter.	Spruce litter.	Oak leaves.	Moss.
Morning temperature	13.24	14.51	15.25	15.00	14.66
Evening temperature	19.11	18.16	18.62	18.24	17.27
Range of temperature	5.87	3.65	3.37	3.24	2.57

The different rates of evaporation from various soil-covers has been carefully investigated independently by Drs. Wollny and Ebermayer. According to Wollny, the unprotected soil evaporated more than twice or three times as much as that covered with litter, while a moss-cover came very near evaporating as much as the open soil. The amounts in grams which were evaporated from a surface of 400 square centimeters during the time from June 6 to September 7 were as follows:

Loam	2,614	Spruce litter	952
Sand	2,011	Beech leaves	724
Moss	1,766	Oak leaves	725
Pine litter	959		

This difference must be accounted for by the difference in physical structure of the material, which either impedes or facilitates replacement of the water evaporated by capillary attraction. Therefore, according to the nature of the forest floor, the rate of evaporation varies.

The experiments of Wollny in 1883 on the amounts of evaporation from soil covered with straw and uncovered are also of interest here as showing the numerical influence of a cover or mulch of dead material, which does not, like the litter, possess capillary forces. The cover in these experiments was 2 inches thick; for a surface of 1,000 square centimeters the amounts evaporated were, during the months of July and August, 571 and 5,739 grams, respectively; that is to say, the naked soil evaporated more than ten times as much as the covered soil.

While in the above experiments the evaporation from the soil-cover was investigated, the Austrian Forest Experiment Stations investigated the influence of moss and litter upon the evaporation from the soil underneath. A fine sand with an average moisture of 4.82 per cent. was covered with various materials, and the amount of moisture which remained in the sand after an exposure for four months

was measured. The amounts lost by evaporation, which allow an estimate of the relative amount of protection of the various covers, were as follows:

	Per cent.
Uncovered sand	54.8
Sand covered with dry earth	40.7
Sand covered with beech leaves (vertical layers)	31.1
Sand covered with beech leaves (horizontal layers)	26.8
Sand covered with beech leaves (kept moist)	0
Sand covered with air-dried spruce litter	34.4
Sand covered with air-dried pine litter	43.6
Sand covered with living grass sod	35.9
Sand covered with living hypnum moss	27.8
Sand covered with living sphagnum moss	6.3

The soil covered with moist beech leaves not only did not lose any moisture but during the first months it absorbed water from the cover, which, however, was lost again later during the warmer weather. The last three covers were kept alive by careful sprinkling in small amounts for three months; this was, however, not sufficient to keep the grass alive to the end of the experiment. The low dense hypnum moss preserved the moisture well as long as it was sprinkled, but when allowed to dry it could do no better than the dry beech leaves. The sphagnum moss, however, continued its protective function even after the sprinkling. The pine litter in an air-dried condition showed but little power of protection; this would have been more effective if, as it occurs in nature always, it had been kept moist.

Altogether, it will have to be admitted that the factor of dissipation represented in the evaporation from the ground is considerably reduced by the forest-cover; and since the rate of evaporation in our western Territories is probably the greatest element in the dissipation of moisture, the greatest attention to checking it will be necessary in the husbanding of water supplies. This check to evaporation refers not only to the preservation of the water supply where it falls, but also in the natural and artificial channels through which it may be conducted or in the reservoirs where it may be stored.

The surface exposed determines the amount of evaporation from water-courses and reservoirs; but if the amount evaporated is related to the available volume of water, it will appear that the smaller and slower run loses proportionately more than the larger, which thus exhibits the value and protective character of accumulation.

Take a brook 6 feet in width and only a foot in depth; this for a length of 30 feet would contain 180 cubic feet of water. If from this surface only one-tenth of 1 inch evaporates, the amount evaporated is equal to 1.5 cubic feet or $\frac{1}{120}$ of the entire supply. On the other hand one-tenth of 1 inch evaporation from a river 60 feet broad and 12 feet deep for a length of 30 feet, containing therefore 21,600 cubic feet of water, would bring the loss to 15 cubic feet or only $\frac{1}{1440}$ of the available supplies; the loss, in proportion to the supply, being twelve times greater in the former case.

Transpiration.—All vegetation takes up a certain amount of water, a part of which is consumed in building up its body, and a still larger part returned to the atmosphere by transpiration during the process of growth.

The quantity of water so used is as variable as the amount of precipitation and in fact within certain limits depends largely upon it. That is to say, a plant will transpire in proportion to the amount of water which is at its disposal. Transpiration is also dependent on the stage of development of the plant, on the nature of its leaves and amount of its foliage, on temperature, humidity, and circulation of the air, on intensity of the sunlight, and on temperature and structure of the soil and on other meteorological conditions. Rain and dew reduce transpiration, wind increases it.

The amount of transpiration depends considerably upon the thick-

ness of the leaves, therefore the surface of the foliage is not a reliable measure, but it should be compared with the weight.

With so many factors to vary them the values which may be given for the amount of transpiration of the various kinds of trees can only be approximations of its range within wide limits. All the figures which have been published, based upon calculations or experiments in the laboratory, are useless for practical purposes. Especially do those figures which represent the requirement of the plant as exceeding the amount of precipitations, exhibit on simple reflection, their absurdity.

If the requirement per acre is considered, the density of the growth of plants must also be taken into account.

The first careful and comprehensive investigations into the water requirements of forest trees were made by the Austrian forest experiment stations in 1878 (F. B. Hoehnel), and full tables of the results obtained can be found in the records of those stations.

An average of the many figures there presented would make the amount of transpiration per 100 grams of dry weight of leaves in conifers 4,778 to 4,990 grams of water, in deciduous-leaved trees 44,472 to 49,553 grams of water. That is to say, the deciduous trees transpired about ten times as much as the conifers, and comparing the two extremes of transpiration, the deciduous tree with the highest rate of transpiration utilized twenty-three times more water than the coniferous tree with the lowest rate. Ash, birch, and linden were found to be the most vigorous transpirers, oaks and maples transpiring much less. Curiously enough, while in the conifers shade reduced the transpiration considerably, in the deciduous trees it had the opposite effect.

During the period of vegetation the following varieties transpired per pound dry weight of leaves:

	Pounds of water.
Birch and Linden	600–700
Ash	500–600
Beech	450–500
Maple	400–450
Oaks	200–300
Spruce and Scotch Pine	50–70
Fir	30–40
Black Pine	30–40

The next season, which was more favorable to transpiration, the amounts were larger; the deciduous trees transpiring from 500 to 1,000, the coniferous from 75 to 200 pounds, or in the proportion of one to six.

The following actual amounts transpired per 100 grams of dry leaves during the third season (1880), will show the relative position of the various species (European):

	Kilograms.		Kilograms.
Ash	101,850	Scotch Pine	12,105
Birch	91,800	Fir	9,380
Beech	91,380	Austrian Pine	7,005
Hornbeam	87,170	Aspen	95,970
Elm	82,280	Alder	93,300
Maple (*A. campestre*)	70,380	Linden	88,340
Norway Maple (*A. platanoides*)	61,180	Larch	125,600
Oak (*Q. robur*)	69,150	Average deciduous trees	82,520
Oak (*Q. Cerris*)	49,220	Average conifers	11,307
Norway Spruce	14,020		

The variability of transpiration from day to day is of wide range; a birch standing in the open and found to have 200,000 leaves was calculated to have transpired on hot summer days 700 to 900 pounds, while on other days its exhalations were probably not more than 18 to 20 pounds.

A fifty to sixty year old beech was found to have 35,000 leaves, with a dry weight of 9.86 pounds; a transpiration at the rate of 400 pounds per pound during the period of vegetation would make the total transpiration 3,944 pounds per tree (about 22 pounds daily); and since 500 such trees may stand on 1 acre, the transpiration per acre would amount to 1,972,000 pounds, while the precipitation during the same period would be 2,700,000 pounds.

The transpiration of a thirty-five-year-old beech with thinner leaves, of which there were 3,000, with a dry weight of 0.79 pounds, would under the same conditions transpire 470 pounds per 1 pound of foliage, or 373 pounds per tree (about 2½ pounds per day from June to November); and since about 1,600 such might be found on an acre, the total transpiration might amount to 596,800 pounds per acre, or considerably less than the amount of rain-fall.

Calculated for summer months during June, July, and August alone, the requirement of the two beech growths was 20,000 and 5,000 pounds per day an acre respectively. Conifers, as was stated, transpire one-sixth to one-tenth of the amount which is needed by deciduous trees.*

I repeat again that these figures can only be very rough approximations denoting maxima of transpiration, and that the amounts transpired per acre depend largely on the amounts furnished by precipitation. Therefore our forest areas within the arid region of the country probably transpire a minimum of water, their scattered growth and their coniferous composition, with the scanty rain-fall, reducing the amounts to lowest limits.

Taking a rain-fall of 20 inches, which represents say 4,500,000 pounds of water per acre, a coniferous forest, assumed to transpire one-sixth of the amount found for the older beech-forest under most favorable conditions of precipitation, would require hardly more than 330,000 pounds (presuming the same weight of foliage), or not 8 per cent. of the total precipitation. To be sure, this amount must be available during the period of vegetation.

Since this water is given off again to the atmosphere in the locality where it has fallen—thus re-enriching the atmospheric moisture—it may be considered as part of the circulating water capital which

*The amounts transpired by agricultural crops and other low vegetation, weeds, etc., have been found to be considerably larger, as will be seen from the results of the latest investigations by Wollny, which I have calculated per acre to make them comparable with the foregoing results:

Agricultural crops.	Time of vegetation.	Water consumption per acre.
		Pounds.
Winter rye	Apr. 20–Aug. 3, 1879	2,590,186
Barley	do	2,720,238
Peas	do	3,144,128
Red clover (first season)	Apr. 20–Oct. 1, 1879	3,070,012
Summer rye	Apr. 20–Aug. 14, 1880	3,000,486
Oats	Apr. 20–Sept. 14, 1880	3,422,584
Beans	Apr. 20–Sept. 10, 1880	3,139,233
Red clover (second season)	Apr. 20–Oct. 1, 1880	4,109,198

does its duty in producing useful substance and in conserving moisture for the locality.

There is still to be considered a certain amount of moisture which is retained and stored up in the body of the plant, partly as a necessary permanent constituent, partly as a temporary constituent, being evaporated when the plant dies or the wood is seasoned. The amounts thus retained vary considerably according to age, capacity for transpiration, site, soil, climate, density, slow or rapid growth, weather, seasons, and even the time of the day. It is therefore almost impossible to give anything but very rough approximations, especially as also the different parts of the tree vary considerably in the amounts of water present.

The water which enters into chemical composition of the wood substance represents round 50 per cent. of the weight of dry substance.

The water hygroscopically retained in the living tree varies within the wide range of from 18.6 to 51.8 per cent. in the wood, while the leaves contain as much as 54 to 65, and some even over 70 per cent. while living; when dry, still 10 to 12 per cent. The wood of deciduous hard woods, like oak, ash, elm, birch, beech, contain in the average 38 to 45 per cent.; soft deciduous trees 45 to 55 per cent., and the conifers 52 to 65 per cent. White pine when young may show as high as 77 per cent. of its weight as water, while larch, of all conifers, has the smallest water capacity, namely, 45 to 55 per cent., ranking with the deciduous soft woods.

This hygroscopic water is reduced by seasoning to 10 or 12 per cent.; this amount being retained even in well seasoned woods.

Given the entire mass of wood and foliage on an acre of forest, an approximative calculation of the total quantity of water contained in the trees will show that 56 to 60 per cent. of the weight of the forest must be attributed to water, while only 44 to 40 per cent. is represented by dry substance. In agricultural crops it is known that the amounts of water are still larger, reaching sometimes 95 per cent. of the whole weight. The production of dry substance in a well-kept dense timber forest may amount annually to from 2,500 to 3,000 pounds per acre, leaving, then, for the hygroscopic water 3,750 pounds, and the chemically fixed water, say, 1,250 pounds; so that for this factor of dissipation 5,000 pounds in round numbers as a maximum will suffice.

ELEMENTS OF CONSERVATION.

In discussing the elements of dissipation as to the degree of their effect under forest-cover compared with the same elements at work in the open field, we have seen that the shade, the low temperature, the relative humidity, the absence of violent air-currents, the water capacity of the forest floor, are all acting as factors of conservation. We have seen that the quantity of water lost by evaporation—the most fruitful source of dissipation—may be more than six times as great in the open as in the forest. There is only one other element of conservation affecting water supplies which requires special mention. This is the retardation in the melting of the snow which is due to forest-cover. According to Dr. Buehler, of Zurich, this retardation in Switzerland amounts to from five to eight days in general, and may, according to weather conditions, be several weeks, thus giving a longer period for distribution. The evergreen coniferous forest in this respect naturally does better service than the deciduous one.

The conservative effect of the forest-cover is especially of value on the western mountain ranges which are liable to be swept by the

chinook, dissipating as if by magic the snow-cover over which it sweeps.

The proposition, then, to remove the forest-cover in order to allow the drifting and compacting of the snow, from which possibly to secure a longer period of distribution even if there were no other objection, must be considered a hazardous and ill-advised expedient.

The influence of the forest upon the condition and drifting of the snow is graphically related by Middendorff in his description of Siberia, speaking of the Buran or snow-storm characteristic of the treeless plains of tundras.

> As far as the forest reaches and impedes the action of the winds the snow lies everywhere evenly and loosely, so that in the beginning of winter one can travel only on snow-shoes. As soon as the tundra is reached there is no need of snow-shoes. The snow lies either like a thin carpet, or drifted together in incredible masses, so compacted as to bear man and beast, etc.

The popular notion which ascribes to the moss-cover or spongy character of the forest floor a conservative function beyond that of retarding evaporation and infiltration seems to be entirely erroneous and needs revision. The idea that the moisture of the soil and the flow of springs is increased by water from the spongy cover is altogether in contradiction to physical laws, and can be shown experimentally to be a mistaken one.

Water filters through the cover by the law of gravitation until the spongy mass has become fully saturated. With an addition of water it will filter through to the soil, as long as the supply continues and the soil is not so saturated that it can not readily absorb any more water. At last, the supply continuing, the cover will refuse to convey it and will shed it superficially, leaving opportunity to reach the soil only where the moss-cover is interrupted. When the water supply ceases, evaporation begins above, and by capillary attraction the cover supplies its loss of water on the surface from the soil below.

To give water to the strata below, it would be necessary that these should have become dry, or at least drier than the moss-cover before the latter had lost its water. This may occur and depends naturally upon the structure and nature of the soil. If the soil is strongly fissured, thus rapidly draining the upper strata, then, if the moss-cover is still saturated and an additional pressure is exerted by water standing or falling on it, a further supply of water may be given up to the soil; if, however, the moss is only just saturated and no further access of water takes place from above, then there is no physical law by which a surrender of this saturation water to the soil could take place as long as the underlying soil is of a gravelly or non-absorbing nature. If its nature is like clay, marl, fine sand, capable of attracting water, then the further process of water absorption depends upon the difference between the water capacity of the cover and that of the soil.

In a sand soil in which the upper strata lose their water rapidly to the lower, the moss-cover, which holds water more tenaciously, can be made to give up water to the soil as long as the capacity for absorption by the sand is greater than the capacity for retention by the moss.

A loam or clay soil takes up water very slowly, but takes up a great deal before it is saturated, and the process of filtration goes on very slowly; if, therefore, a plentiful rain falls, there is formed

under the moss-cover a shallow, nearly saturated layer of soil, which acts as an impermeable stratum. This layer is protected by the cover against rapid surface drying, and since it gives up its water only slowly to the lower strata, it remains moist so long as the moss-cover is not dry. As soon as by evaporation the cover has lost its water, which it does rather rapidly, the soil must give up some of its moisture by capillary attraction to supply the deficiency in the cover. A deficiency of moisture occurring in such soil earlier than in the cover can be presumed only when the water is utilized by the roots and transpired; but as such transpiration water is dissipated and does not increase the run-off, the process can not be considered a conservative one.

These are the extreme cases between which in nature many intermediary conditions occur. The litter cover does not act analogously to the moss-cover or to a sponge. A difference must here be noted between the newly fallen loose litter of the previous year and the closely packed and felted litter accumulations of former years. The former allows a rapid filtration; the latter, according to Riegler's experiments, is nearly impermeable, and the water practically can enter the soil only where the litter is interrupted. The compacted litter serves admirably to retard evaporation. In reality there rarely exists an uninterrupted cover of such litter or a cover of one uniform nature; open spaces, moss-covers, varying thicknesses of litter-cover interchange, and accordingly the water penetrates readily, while the cover performs its duty as a conserving agent against evaporation.

It is, then, *the protection against evaporation alone*, due to greater relative humidity of the forest air, to the shade, to the breaking of the winds, and to the protective soil cover, which *makes the forest a conservator of moisture everywhere*, even where it does not by its peculiar location increase the amount of precipitation.

Springs, then, may be influenced in the amount of their discharge by a removal of the forest; not because the forest supplies them directly with more water, but because by its removal the rate of evaporation is increased.

The total conservative action of the forest with reference to available water supplies, aside from an increase of precipitation, is expressed by the difference between the elements of dissipation and those of conservation; the former comprised in the loss of the water by retention or interception, evaporation, and transpiration, the latter in the protection against evaporation. This balance is known to be in favor of the forest cover in some localities and under certain given conditions; but it will have become apparent that a general statement or quantitative expression of the amount of benefit would be well nigh impossible.

Water supplies remaining available.—As will have appeared from the foregoing statement it is almost impossible to calculate the difference between the precipitation on one hand and evaporation and transpiration on the other. Yet in an ingenious manner a calculation for one of the Prussian mountain districts is proposed by Dr. Weber as follows: Using the figures which are exhibited in the table on page 309 he argues that the amount of water left over and above the amount evaporated in the open at low altitudes, deducted from the amount left over and above evaporation in the forests of high altitudes, will suffice to cover the amount of transpiration; thus, in the spruce forest at the station of Sonnenberg, the surplus of precipita-

tion above the water needed for evaporation had been 1,093.8 millimeters; deducting from this the quantity which was found remaining in the open at Schoo, and which would suffice for purposes of transpiration and plant growth, a balance for drainage of 771.3 millimeters results; for the beech forests at Melkerei and Hadersleben, the calculation gave a balance of 1,176.8 — 495.8 = 681 millimeters for drainage. On the average, therefore, 700 millimeters of the precipitation in the mountain forest in this locality are saved for the "run-off," that is, 100,000 cubic feet of water per acre.

To get a conception of what these 100,000 cubic feet mean in the river flow, it may be stated that with average water level the Rhine above Mannheim has a flow of 47,700 cubic feet per second, an amount which would be yielded by 40,000 acres of mountain forest, provided all water is drained into the river; and to keep the river continually flowing at this rate would require, on the basis of these figures obtained experimentally, a forest area of 23,472 square miles, a calculation which by no means leads to absurd results for practical probability, since the drainage area of that part of the river is in reality about 30,000 square miles, largely in forest.

ELEMENTS OF DISTRIBUTION.

The distribution or "run-off" of the available water supply is almost as important and often a more important factor in the economy of the water than the quantity of available supply itself, and the manner in which this takes place influences considerably the ultimate availability of the supply for human use.

This distribution of water proceeds under the action of two natural forces, gravity and capillarity.

These two forces are acting in opposition to each other, a fact which is often overlooked. Under the action of gravity the water seeks a lower level; the action of capillarity tends to elevate the water. The movement of the water in the soil is therefore a resultant of these two forces, and since gravity remains constant but capillarity is variable according to the structure of the soil, the latter force and the conditions upon which its action depends are the most important factors in determining the nature of the distribution or run-off of the water.

After precipitation has reached the ground its run-off is influenced by surface conditions of the soil-cover, by the structure and stratification of the soil itself, its water capacity, its permeability and other physical conditions; further, its slope and also its liability to disintegration and to form detritus under the erosive action of the water; further, upon the topography of the ground and such elements as modify soil-cover, soil conditions and topography.

There are two methods of distribution or run-off, namely, the superficial or surface run-off, and the underground run-off resulting in springs which eventually change into open runs, brooks, and rivers.

To understand any influence upon the run of water in springs and brooks a brief consideration of the nature and essential features of springs and open runs is necessary.

Springs.—A spring is that place where the water which has penetrated the soil re-appears collected on the surface. Springs are in most cases the beginnings of brooks and rivers. According to the manner in which the percolated water reaches the surface, springs may be classed as standing and running springs.

The standing or ground-water springs are such as collect water in some depression of the soil and overflow only as long as the water reaches the lower level of the outlet. Their formation is easily understood from the accompanying figure (I), in which (1) represents a hill-side of massive rock, continuing under the overlying strata at *a*. The latter consist of impermeable strata (2, 2) (clay, loam, marl); above this

a layer of gravel or coarse sand and rock material (3), and above this a stratum of soil (4), which at X is absent, leaving an open bowl where the gravel layer becomes visible. All the rain-water falling on the plateau *o p* and on the slope *o a* running

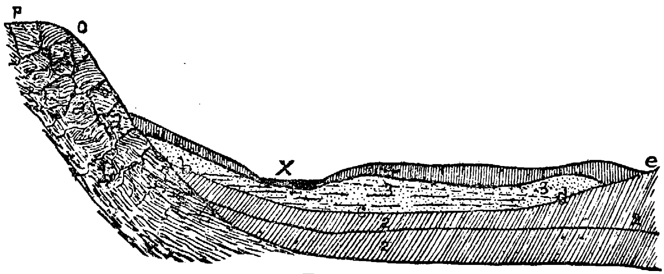


FIG. I.

down, when arriving at the impenetrable strata near *b*, will be diverted into the gravel bed and spread in this, being prevented by the underlying impermeable strata from sinking. When sufficient water is supplied the water level rises until it appears at X, and if there is an outlet over the rim of the bowl and sufficient slope of the ground the spring begins to flow, forming, it may be, the beginning of a brook. Such a standing or ground-water spring ceases to run if precipitation cease for a length of time sufficient to reduce the water level below the outlet. Similar conditions can occur alongside of rivers when the seepage of the river supplies the water to a spring below the river level, and the level of these seepage waters rises and falls, of course, with the rise and fall of the river level.

Of running springs, there may be distinguished, according to the manner of their formation, three kinds—soil or surface springs, fissure springs, and cavern springs.

A surface spring originates when a more or less impermeable soil forms part of or lies near the upper soil stratum, allowing the water to enter only imperfectly and to an inconsiderable depth, and, passing through the looser parts of the soil, to collect and come to the surface at some point where the top soil is absent. These shallow-soil springs naturally vary quite sensibly, according to the physical conditions of the surface, and are dependent directly on the precipitation; dry up easily if it does not rain or if the soil is exposed to insolation and is deprived of shade; they are warm in summer and freeze out in winter. They are usually found in localities where the rock consists of easily disintegrated clay slates and sandstones, capped with a shallow layer of decomposed rock, or in the neighborhood of loam hills. An addition of broken rock and stones to the soil facilitates the penetration of the water and increases the comparative flow of these springs.

Whole districts along the foot of the Alps in Switzerland, Bavaria, Austria, and the Carpathians in Galicia, etc., have hardly any other kind of springs.

The second class, conveniently called "fissure" springs, originate from waters which have deeply penetrated the soil and rock through the fissures, rents and splits, or numberless cleavage strata of the upper rock formations, and ultimately reach a deeper-lying inclined rock formation, which prevents further penetration and causes

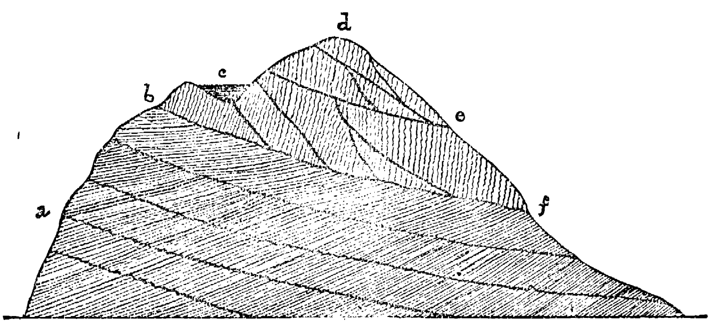


FIG. II.

the water to run along its upper plane until the formation somewhere comes to the surface and with it the collected water of the spring. These conditions are illustrated in the accompanying cut (fig. II), in which *b c d e f* represents the upper fissured

formations through which the rain and snow waters penetrate to the lower impermeable strata below the line *b f*, necessarily gravitating to point *f*, where the opportunity for discharging as a spring exists; a smaller spring might occur at *e*. Such conditions exist where lime or dolomite rocks overlie hard sandstones, compact clay slates, or clay beds. These springs, as a rule, are much less dependent on the changes of precipitation and temperature; they are mostly continuous and even in their flow and their temperature.

The third class of the running springs may properly be called "cavern" springs, from the fact that while their waters are drained like those of the second class, they are first collected in some subterranean basins or caverns, and appear on the surface as overflow of these basins.

In the accompanying figure (III), *a b c* is the catchment basin, from which the vari-

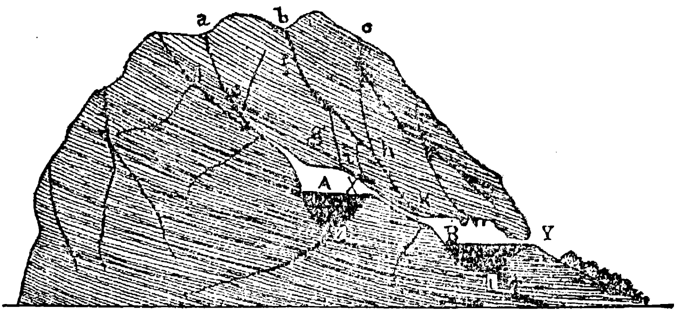


FIG. III.

ous fissures conduct the water to *A*, overflowing at *X* into *B*, and from there overflowing and appearing at the surface at *Y*.

This kind of spring is found frequently in limestone formations, and since the water of such often come from great distances from above their discharge at the surface, they are usually of very cold and even temperature; they are apt to run low when the soil is frozen and when precipitation is small, and their discharge is more or less intermittent. The obstruction of the old and opening of a new outlet by a fall of rocks at *X* and *Y*, and the widening of a formerly insignificant fissure at *z* or *t*, may reduce the flow or stop the original spring entirely, opening a new one in an entirely different part of the locality.

While we have here considered conditions under which springs are formed, there are also conditions under which their formation is excluded; such might be found in extended plains or low hill lands, with a compact, impermeable soil which may give rise to pools and morasses but not to springs. Plateaus of fissured limestone dolomites or of compact gneisses or granites may also be poor in springs, their waters sinking at once to such depths that no discharge is met in the immediate neighborhood of the catch-basin, or else shedding the water at once superficially.

The object of this elementary explanation of the formation of springs is to show that geologic conditions to a large extent influence the manner in which the waters falling on a certain territory are collected and discharged or distributed in underground channels, and that, in spite of favorable forest conditions, a region may be poor in springs and without any disturbance of the forest cover a change in the run of springs may occur.

The water of the springs finally flows off in open runs, brooks, rivers, and lakes to the sea. Besides, there is a certain amount of water running off the surface without first penetrating the soil or having been collected in springs; this run-off takes place during precipitation and melting of snow, finding its way through smallest furrows in the soil surface, or directly over the surface and slopes in trackless courses into the open runs.

These are the waters which occasion the dangerous floods, which fill the channels that were dry before, and give rise to so-called

torrents, to freshets, and to a great waste of available water supplies by the rapidity with which they are collected and carried off.

The watercourses which rely on this source of supply must naturally differ from those supplied by springs in the uncertain change and fitful state of their water conditions.

Between these two main types of "run-off" there are intermediary types, which supply themselves by both methods in varying degree; a stream may begin as a torrent and later in its course find additional supplies from springs, or the reverse may take place—being originated by a spring it may have no other additions except from the superficial run-off. It is evident that the conditions for a superficial run-off are to be found, first, in the amount and nature of precipitation, and next in the soil and surface conditions.

A violent rain-storm will naturally furnish more superficial run-off than when, the rain falling slowly, time is given for the soil to absorb it; a snow-cover fallen on frozen ground is apt when melting to shed its water over the frozen surface without penetrating the soil.

Nature of soil and soil-cover and topography determine, with equal amounts of water to dispose of, what the nature of the run-off will be. An impermeable soil takes up sufficient water to make it plastic and then sheds all additional water superficially; a permeable soil continues to take up water and conducts it into the depth. This difference of behavior must influence and determine largely the conditions of any river-bed; for if it run for some distance through impermeable soil, even insignificant rain-falls will rapidly collect and swell the river, while the permeable soil would have taken up and held all or parts of the precipitation and would only gradually have given it up.

Since the amount of superficial run-off is in inverse ratio to the amount drained off by springs, it follows that, where superficial drainage is the rule, the supply to springs is scanty, and *vice versa.*

The topography determines the rapidity of run-off and of collection. The more diversified the country—cut into dells, coves, rills, and furrows, steeper and less steep slopes—in the greater number of runs of unequal length is the water collected, while the less diversified the contour the more water must be carried off in each run. Yet where the diversity of configuration is accompanied by steep slopes the run-off may be so rapid that the valley river is filled more rapidly than the river of the open plains country with even slopes of moderate inclination.

Thus in some of the river valleys of West Virginia the water-sheds are scooped out into such an array of coves, gashes, and water-courses and minor water-sheds, and so steep and rapid in descent that, in spite of the forest cover, a rain-fall of a few days will induce a rapid rise of the rivers, while the same amount of rain will hardly wet the ground in a prairie country like Iowa.

As regards soil and surface conditions it is obvious that the less permeable the soil or soil-cover the less the absorptive capacity of the same, and the fewer mechanical obstructions are met the more water runs off superficially.

An additional factor in determining the nature of superficial runs is the amount of rock material and soil which they carry. Since this detritus is deposited wherever the velocity of the water sinks below that necessary to carry it, forming sand-banks and rubbish-heaps which obstruct and change the direction of the run, it plays quite

an important part in shaping the bed of the river, besides influencing the whole system of dependent brooks and rivers. And in this the nature and shape of the detritus—whether fine sand or earth, smaller or larger rock masses, stones, roundish, square, or flat—cause much difference; and this in turn depends upon many conditions, geological and climatical.

According to the nature of the rock from which it is derived, the detritus appears in different shapes, which again changes in form during its further transportation by the waters in different ways, and therefore exerts a varying influence upon the run. Thus the detritus, which appears in large plates or shales, is carried more easily than the square or round rocks; the former, even when deposited, hinders the flow of water between the plates but little, and therefore gives less cause for stow-water than the heavy square rocks, which resist the transportation and obstruct the flow more effectually.

Sand and gravel detritus is easily carried, easily accumulated, and again with a new flood easily removed; it offers, therefore, little resistance to the flow of water, but becomes objectionable in filling the lower channels of rivers, etc.

Clay detritus, although easily carried, is apt to compact and cement the rock detritus together, and thus becomes one of the worst impediments of water flow and is the cause of the worst dangers from flood waters.

From these examples it is apparent that two rivers, although under similar conditions of rain-fall, physical conditions of soil and topography, may yet have a different behavior, according to varying character of the detritus.

As to the amounts and nature of precipitation we must keep in view rainy and rain-poor localities, short and insignificant rains, short but violent, long and mild, or long, plentiful rains; also periodical, seasonal rains and irregular rain-falls. The effect of these differences in the nature and time of occurrence of the rain-fall must naturally affect the nature of the run-off. The effect is still further complicated when the precipitation is partly snow, when not only the mass of accumulated supply but also the progress of melting determine the result of the run-off.

Therefore we find based upon this one factor, namely, the nature and time of occurrence of precipitation, differences in the run-off which are dependent upon differences in climatic conditions. Thus tropical rivers show one or two regular high stages of water according to whether they have one or two rainy seasons; in regions of equinoctial rains a spring and fall freshet is normal, while the rivers may be almost dry in summer or winter; the frequent thunder-storms in the mountains of Switzerland produce short but rapid floods during the summer, while the fall is characterized by low water in the rivers. This climatic difference in water-flow it is important not to forget when discussing the influences which may modify the discharge of waters.

With these premises as to the general nature and conditions of run-off we can now discuss the variable influences which may change or modify the manner of distributing the water though springs and open channels.

In general, the amount of water in springs and open runs depends on the area of the catch-basin; *i. e.*, the area from which the precipitation is drained into the springs or runs, and further on the amount and frequency of the precipitation; but the manner of its disposition

and its distribution, as we have seen, depends mainly on conditions of soil and soil-cover.

On a given territory with given geological, topographical, and climatic conditions, the only directly variable conditions are those of the upper soil-strata and of the soil-cover.

We are interested, therefore, mainly in determining not only the water capacity of soils and soil-covers, but also the intensity of their water absorption and the amounts of water which are drained through them in given times. We are interested in studying by what means the draining capacity of the soil is increased, and by what means altogether the run-off may be changed in its nature from a superficial to a subterranean one and the reverse.

Unfortunately the material for the discussion of these points is still meager and unsatisfactory.

The water capacity of soils and soil-covers in general has been referred to as an element of interception. With reference to the run-off, this capacity becomes influential in determining the manner of run-off. As soon as the soil-cover and the upper soil-strata are saturated, and especially when the latter are impermeable and the rain continues, either no water or only a small part gradually can find entrance into the soil, and the run-off becomes superficial, or, if the ground be not sloping, stagnant water results.

For every forest there is, therefore, a time when the superficial run-off would be no more impeded than from an open field of similar conditions but for the retardation by the trunks, underbrush, and roots. This time, however, occurs later in the forest than on the unforested and especially naked soil, because the water capacity of the soil-cover as well as of the protected soil is greater than that of the naked soil or that covered with field-crops.

In addition to the experiments in this respect cited on page 305, we give the following results of the experiments of Dr. E. Ebermayer, which refer to the amount of water contained in a heavy loam soil under a forest of spruce twenty-five, sixty, and one hundred and twenty years old, and a naked soil at 16-inch (40 centimeters) and 32-inch (80 centimeters) depth.

Water contents of a loamy sand; results by seasons expressed in percentages of the weight of the soil.

Season.	Spruce.									Naked soil.		
	25 years old.			60 years old.			120 years old.					
	16 inch.	32 inch.	Average.	16 inch.	32 inch.	Average-	16 inch.	32 inch.	Average.	16 inch.	32 inch.	Average.
Winter (January and February)	20.23	17.00	18.61	18.06	17.76	17.91	19.75	22.44	21.09	19.96	24.73	22.35
Spring (March to May)	18.62	18.02	18.32	15.29	16.28	15.78	17.47	20.83	19.15	20.66	20.51	20.58
Summer (June to August)	15.10	16.22	15.95	14.42	17.03	15.72	17.78	20.90	19.97	19.97	19.98	19.97
Fall (September to November)	16.57	17.57	17.07	13.49	16.52	15.00	14.88	19.46	17.17	20.04	20.20	20.12

These figures show that a loam soil under forest cover is apt to be drier in the depth of the root-region than in the open field, less so under an old and scattered growth than under a younger growth or thicket, and that at all seasons.

A repetition of these experiments, in which depths from the top to 32 inches were included, gave during two years the following averages of water capacity, expressed in percentages of the weight of the soil:

Averages of water capacity, expressed in percentages of the weight of the soil.

Depth.	Spruce.			Unshaded soil.
	25 years old.	60 years old.	120 years old.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
0 to 2 inches	30.93	29.48	40.32	22.33
6 to 8 inches	19.19	18.99	19.30	20.62
12 to 14 inches	19.10	16.07	18.28	20.54
19 to 20 inches	18.40	16.26	20.16	20.14
30 to 32 inches	17.91	17.88	21.11	20.54
Average	18.65	17.30	19.71	20.46

Ebermayer combines the values for depths from 6 inches down to 32 inches, and then concludes that the forest soil is less moist, due to the transpiration of water by plants. This conclusion is, however, not at all warranted. For if one combines the figures found in all the strata from top to 3 inches down, they figure as follows: Spruce twenty-five years old, 24.79 per cent.; spruce sixty years old, 23.39 per cent.; spruce one hundred and twenty years old, 30.01 per cent.; naked soil, 22.39 per cent.

Hence, take it altogether, the naked soil contains considerably less water than the forest-covered soil. But the distribution of the water through the different layers of the soil is different in the two cases; the naked soil, due to rapid evaporation no doubt, contains the least amounts in its upper strata, where the forest soil with its absorptive cover preserves the largest amount. Measurements of the stratum from 2 to 6 inches would probably have shown the preservative effect still more prominently.*

Nor is the further conclusion of the eminent author warranted, that this condition of things necessarily influences the effect of forests on springs. This is more dependent on the porosity of the soil, due to the mechanical protection which the soil-cover offers against the compacting effect of raindrops and to the numberless channels which growing and decayed roots offer to conduct the water into the depths.

In regard to the water supply of springs, Ebermayer maintains that the forest reduces it more than uncultivated naked soil but less than meadows and uncultivated fields, but that the forest has great significance for the preservation of existing springs. Therefore, extensive deforestation will result in reducing the supply to springs, because the deforested soil covers itself soon with grasses and weeds, which require more water and furnish less drain-water than the forest.

* How much water the soil-cover can contain appears from the following measurements of Dr. Ebermayer: On the 17th of August, 1885, after rainy weather, the moss-cover in a sixty-year-old spruce growth contained 72.33 per cent. at the top; 76.64 per cent. on the lower side, and 71.67 per cent. in the humus soil beneath.

After a rain-storm lasting one and a-half days, on September 9, 1885, the moss-cover contained 80.45 per cent. at the top; 74.61 per cent. on the lower side, and 74.42 per cent. in the top soil.

Of still more importance for the run-off than the water capacity is the water conductivity of the soil, or, as I should call it, the intensity of water absorption.

The rapidity with which the water is conducted from above downward must necessarily influence the nature of the run-off.

Gravity tends to drain the water downward, capillarity to carry it upward; the difference of these two forces in the main must, besides the mechanical obstructions of the soil particles, determine the rapidity of drainage. Experiments to establish the rate under various conditions are very few and unsatisfactory.

The capillary conduction from below has frequently been made the subject of investigation, but the downward movement has not yet been studied with sufficient detail, and it has hardly yet been recognized by the experimenters that this depends upon the difference of gravity and capillarity as two opposed forces.

Accorning to E. Wollny's experiments in 1883 and 1884—

(1) Water is conducted downwards the more rapidly the larger the soil particles (*i. e.*, the less capillary attraction exists).

(2) The non-capillary interstices of the soil accelerate the downward movement of the water (*i. e.*, the less mechanical obstruction of soil particles).

(3) In granular soil the water penetrates faster than in powdery soil (*i. e.*, penetration is the slower the denser the stratification). It is most rapid in quartz and slowest in clay; in humus at a rate between these two, but in a mixture of clay soil and humus faster than the average of the two.

(4) The rapidity of drainage in a granular soil is independent of the size of the grain.

The experiments were made with soils of varying grain in tubes 110 centimeters deep, the water dropping on top constantly; the results are exhibited in the following two tables:

Water conductivity in soil with varying size of grain.

Soils.	Water sank to a depth of—						
	After 5 minutes.	After 10 minutes.	After 15 minutes.	After 25 minutes.	After 45 minutes.	After 65 minutes.	After 120 minutes.
In soil of grain:	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*
0.01 to 0.071 millimeters	8.8	12.8	16.2	21.3	30.0	36.7	52.0
0.071 to 0.114 millimeters	18.0	27.0	37.0	52.5	79.0	103.0	....
0.114 to 0.175 millimeters	28.3	43.0	65.0	96.0	....	....	....
0.175 to 0.2 millimeters	45.0	82.0	110.0	....	....	....	....
0.25 to 0.50 millimeters	84.0	....	....	....	....	....	....
Mixture of various grains	11.0	19.0	24.5	33.2	50.8	65.5	106.0

Water conductivity in granular soils.

Soils.	Water sank to a depth of—					
	After one-half hour.	After 1 hour.	After 3 hours.	After 4 hours.	After 23 hours.	After 59 hours.
Loam powder:	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*
0 to 0.25 millimeters	9.0	12.1	20.2	23.4	57.4	97.6
0.5 to 1.0 millimeters	18.8	32.1	82.4	100.0	....	....
Loam granules:						
1 to 2 millimeters	19.0	32.2	83.1	100.0	....	....
2 to 4 millimeters	19.3	32.0	81.[illegible]	100.0	....	....
4 to 6.75 millimeters	18.8	30.4	77.5	99.6	....	....
6.75 to 9 millimeters	18.5	31.0	80.5	100.0	....	....
Mixture	4.0	8.0	11.0	19.5	24.1	100.0

According to Fesca the downward movement proceeds quickest in a dry dust, only slowly in clay soils; the same amount of water being drained through the former in one hour which it took two days to drain through the latter.

The influence of a soil-cover on the condition of soils was investigated directly by Wollny; he comes to the result that vegetation and cover with dead material (straw, litter, etc.) tend to preserve the loose granular structure of the soil.

Now, since the forest cover has a tendency to preserve the granular porous structure of the soil, which is favorable to filtration, and as moreover the roots furnish channels for unimpeded drainage, it must have the tendency, other things being equal, to allow a more rapid filtration than the naked, mostly compacted soil. The temperature too appears to have an influence favorable to rapid filtration in the forest, for, according to Pfaff, in the field during winter three-quarters of the precipitation will sink to 2 feet depth in the soil, and not more than 10 to 30 per cent. in summer.

Unless, therefore, the forest cover itself had a tendency to retard penetration, which we will see is not the case, the influence of the forest upon the intensity of water absorption would be in the direction of diminishing superficial flow.

This factor is of the utmost importance in the discussion of the causes of floods. Without a consideration of the water capacity, and still more of the intensity of water absorption, it will never be possible to draw conclusions as to probable floods from the amount of precipitation alone.

The influence of various soil conditions and soil-covers upon the amount of water that will filter through has been investigated by Wollny and Ebermayer in an extended series of experiments.

Experiments of this kind which will yield results applicable to natural conditions are exceedingly difficult to arrange, and require not only many precautions but must be continued for a long time before generalizations can be attempted. One of Wollny's series of experiments attempted to show the influence upon filtration of a grass-cover on different soils. The results calculated for an acre are as follows:

Kinds of soil.	Amount of filtration.	
	Fallow field.	Grass covered.
	Pounds.	*Pounds.*
Calcareous sand with humus	1,593,216	782,334
Quartz sand*	3,044,250	661,548
Loam soil*	1,529,671	59,105
Peat soil	2,048,124	405,162

*From May to November.

The grass-cover, therefore, reduced considerably (by 50 per cent. and more) the percolation of water. Ebermayer experimented with boxes 43 square feet surface (4 square meters) and 4 feet deep, filled with fine garden soil, leaving one bare, covering another with moss and two others each planted with six-year old plants of beech and of spruce, with the following results arranged according to seasons:

Year.	Rain.	Filtration water in height—			
		Under beech.	Under spruce.	Under moss.	Naked soil.
1886.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
March to May	156.98	12.65	10.52	16.96	10.93
June to August	560.22	15.89	12.09	31.60	26.13
September to November	114.45	1.12	0.76	7.17	3.27
December to February	126.30	9.73	5.98	11.40	9.08
Total	957.95	39.39	29.35	67.13	49.41
1887.					
March to May	219.20	10.61	5.05	14.40	9.97
June to August	210.60	2.50	1.49	13.00	3.91

In these experiments it is remarkable how small a percentage of the rain-fall was filtered through, which would lead us to look at the results with caution, namely: Of the total rain-fall was filtered—

	1886.	1887.
	Per cent.	*Per cent.*
By soil covered with moss	7	6.2
By soil naked	5.1	3.5
By soil covered with beech growth	4.1	2.9
By soil covered with spruce growth	3	1.5

In regard to the amount of filtration which various soil-covers allow, we have the following very instructive results from the experiments of Wollny, in which the amounts of rain and corresponding filtration on 62 square inches surface are given:

	May to September, 1886 — total rain 28,529 grams.		April to September, 1887—total rain-fall 18,652 grams.	
	Amount, grams.	Per cent. of rain-fall.	Amount, grams.	Per cent. of rain-fall.
Oak leaves:				
5 centimeters	17,591	61.7	7,894	42.3
10 centimeters	19,482	68.3	7,353	39.4
20 centimeters	21,160	74.1	12,954	69.4
30 centimeters	21,061	73.8	13,272	71.2
Spruce litter:				
5 centimeters	17,793	62.4	8,653	46.4
10 centimeters	19,277	67.5	7,356	39:4
20 centimeters	19,523	68.3	14,611	78.3
30 centimeters	19,467	68.2	13,912	74.6
Pine needles:				
30 centimeters	19,734	69.2	9,784	52.4
Moss:				
5 centimeters	14,993	52.5	7,260	38.9
Bare soil:				
30 centimeters	11,610	40.7	3,636	19.5

These figures show that a litter will filter considerably larger amounts of water than a soaked soil of the same depth, and that the moss cover allows less water to filter than the litter. This is accounted for by the soil needing a larger amount of water to supply the moisture evaporated than the litter which remains moist.

Notable is the influence which the thickness of the cover exerts upon the amounts of drain water and also the relation of the amount of precipitation to the amount of filtration.

It will be noticed that with a thicker cover to 1 foot in depth (30 centimeters) the amount of precipitation hardly changes the amount of drain water, while the lighter covers have much less power to preserve a small precipitation, for of course the amounts not drained are evaporated.

We come then to the conclusion that a forest floor, although retaining much of the water in its upper strata, renders the soil more permeable and therefore allows less water to run off superficially.

With regard to the superficial run-off, without any evidence furnished by experiments, we can at once understand that it is impeded by any kind of mechanical obstruction, such as is offered by the vegetation of a meadow or of a forest.

The great number of inequalities which the forest floor offers in addition to the trunks and stumps and fallen trees subjects the run-off to many detours; thus retarding its flow and its collection in the open runs and brooks. This retardation is increased by the mechanical obstruction which the crowns of the trees exert upon the rain-fall. Every leaf, every twig breaks the force and retards the fall of

the raindrops, allowing those fallen before to penetrate the soil. And although, as we have seen, the amount of water which is thus lost to the soil is by no means as large as has been believed (see p. 305), the devious ways in which it reaches the soil makes the flow of water from a forest-covered hill longer in time than if the rain had fallen on a bare slope.

This mechanical effect is further favorable to the penetration of water into the soil, as it prevents the rain from compacting the soil; preserving thereby the mellow condition of the soil, which is destroyed on the open field by the force of the raindrops. It also allows more time for the absorption of water by the soil.

There is, in fact, no influence of the forest of more moment in the distribution of the available water supplies than the mechanical retardation of the "run-off," while in the conservation of supplies the retarding influence upon evaporation is the potent one.

There occurs, to be sure, as the result of long-continued precipitation, a stage when the run-off is hardly more impeded by the forest than it would be under the same conditions by an unforested slope, but this stage occurs in the forest *later* than on unforested soil and later still than on naked soil.

Still more effectual and beyond all dispute is the office of a forest cover in averting or diminishing the torrential action of water in carrying and depositing the debris or detritus in its course, and, as we have seen, the detritus affects the nature of the run-off considerably, narrowing the channels, filling the river beds, causing stowage and floods in the mountain valleys and upper river systems.

The history of the mountain torrents in southern France has proved, if proof were needed, not only the effects of deforestation, but also that reforestation of the denuded hills is the only proper remedy for the regulation of these torrents.

We can not go into the discussion here of the effect which the forest influence upon the head-waters causes in the water conditions of the rivers, since it can not be done briefly, local and purely meteorological conditions giving rise to many differences.

I can point out only a few considerations affecting this discussion, which are apt to be overlooked.

In dry times the retention of the waters by the forest may affect the river flow unfavorably, although for a time the protection which it furnishes against evaporation may keep up the supply more continuously. Whether this conservative effect outbalances the former retentive one depends on local conditions. During ordinary rainy seasons, without excessive rain-falls this effect of a forest cover will act as a regulator of the run-off, and therefore of the river flow.

In seasons of abnormal rain-falls the regime of rivers will show different behavior in different parts, according to differences of condition at the head-waters, the middle, and the lower course.

The first cause of abnormal floods is the occurrence of abnormal rain-falls or the sudden thawing of abnormal masses of snow. If the former occur after the soil has been saturated, or the latter when the soil remains frozen, the forest cover will be powerless to influence the run-off and will shed the water as rapidly almost as the open ground, although even the brief retardation of the confluence of water masses which the obstacles of a forest growth cause, may, under certain circumstances, become important.

But in its further course the drainage of this water, collected in the runs, is favorably influenced by the presence of the forest, it hav-

ing prevented the formation and deposition of detritus in the river bed.

In the main river, which consists of the confluence of many affluents, the effect of flood waters depends almost entirely upon the comparative lengths of the affluents, or rather on the simultaneous or non-simultaneous arrival of the flood waters. A deforestation in one of the side valleys may, therefore, be an advantage or it may be a disadvantage, while a retardation of the total flood, which can only be for a few hours, would be of no account in the main river.

An interesting note as to the amount of retardation which may be produced by the artificial means employed in the French Alps for regulation of water-flow, namely, forest-planting in connection with overflow dams, is given in M. Mathieu's work on "Reboisement in France."

The two basins of Faucon and Bourget were visited by a terrible downpour of rain of twenty-five minutes' duration. In the upper mountains there fell 42 millimeters, in the lower regions 12.3. The torrent of Faucon (which was in a devastated, deforested condition, but otherwise topographically similar to that of Bourget) was at once filled with flood waters which were estimated to consist of 60,000 cubic meters of water and 180,000 cubic meters of rock material or detritus, the flood subsiding in two hours.

In the torrent of Bourget, which had been reforested and corrected in its bed, a simple, somewhat turbulent run of water was observed, which at the overflow reached the height of 45 centimeters (18 inches) and lasted about three hours. The report continues:

> These facts show the importance of the forest cover. Thanks to the dense forest growth planted, the flood waters, divided in numberless runs and retarded constantly in their movement over the declivities in the upper basin, arrive only successively and little by little in the main bed, instead of those formidable masses of water and débris which rapidly agglomerated rush into the channel; the brooks called to replace the torrents receive only pure water; flood waters flowing off gradually and made harmless by the regulation of the torrent bed and of the slopes.

The beneficial influence of the forest in case of abnormal floods can then probably be claimed only in so far as it protects the slopes against abrasion and the formation of debris or detritus with which the upper head-waters are filled, and which carried down into the rivers give rise to sand-banks and changes in the river-bed which may affect the next flood.

We may now attempt to summarize briefly what can be said of the influence which a forest cover may be expected to exert upon the distribution of available water supply or the run-off.

In regard to springs.—The moss or litter of the forest floor retains a large part of the precipitation and prevents its filtration to the soil, and thus may diminish the supply to springs. This is especially possible with small precipitations. Of copious rains and large amounts of snow water, quantities, greater or less, penetrate to the soil, and according to its nature into lower strata and to springs. This drainage is facilitated not only by the numerous channels furnished by dead and living roots, but also by the influence of the forest cover in preserving the loose and porous structure of the soil.

Although the quantity of water offered for drainage on naked soil is larger, and although a large quantity is utilized by the trees in the process of growth, yet the influence of the soil-cover in retarding

evaporation is liable to offset this loss as long as the soil-cover is not itself dried out.

The forest then *may* not permit larger quantities of water to drain off underground and in springs, but it can influence their constancy and equable flow by preventing loss from evaporation.

In regard to surface run-off.—Small precipitations are apt to be prevented from running off superficially through absorption by the forest floor; on larger falls of rain topographical and soil conditions have eventually more influence in this respect than the forest floor; regions with steep declivities and impermeable soil will shed the waters superficially in spite of and over the forest floor as soon as the latter is saturated.

The influence of the forest on such waters is to retard their movement over the surface and to prevent their rapid collection into runs. By preventing the formation of detritus and carrying off debris, the disturbances in the open runs below are prevented or abated.

Upon the water flow of rivers and streams which move outside these mountain valleys with lesser grades the forest along their banks has but little influence; but at the headwaters the influence may be considerable by retarding the collection and arrival of waters in the main river-bed, and thus reducing the danger of the flood.

B. E. FERNOW.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTION.

SIR: I have the honor to present herewith my annual report as Entomologist for the calendar year of 1889. In accordance with your instructions the report has been greatly curtailed as compared with those of previous years. No extensive articles and few of the necessarily scientific details of the work of the Division are included. It is a practical summary of the work, arranged in accordance with your circular of instructions dated November 25, and kept within the thirty-page limit assigned.

BUSINESS OF THE DIVISION.

The sums appropriated for carrying on the work of this Division did not exceed those of last year nor of several previous years. The lump sum of $20,000 was appropriated for general investigations, and the salaries of the Entomologist and four assistants or clerks were otherwise provided for. From the general appropriation are defrayed the salaries of two special assistants, two clerks, an artist, a messenger, and seven permanent field agents. Three other field assistants have been temporarily employed, and an additional office worker has been upon the rolls for a portion of the year. The remainder of the appropriation has been or will be expended in the payment of traveling expenses, the conducting of experiments and field observations, the purchase of insecticide apparatus and insecticide substances, the employment of occasional field help, the purchase of office apparatus (including cases, boxes for collections, microscopes, breeding cages, the numerous instruments and substances used in the rearing of insects, and in the preparation of permanent collections), as also in the preparation and reproduction of illustrations.

WORK OF THE DIVISION.

As shown in former reports, the time of the office force of the Division, as at present constituted, is largely taken up with routine work, consisting chiefly of correspondence, determination of material sent in for name, care of collections, care of the living insects upon which observations are being made in the vivaria, the making of notes, the preparation of drawings, the reading of proof, and the preparation of the manuscript of the reports and bulletins of the Division; while my own time, in addition, is much occupied, as also that of my first assistant, by calls from persons seeking information concerning injurious insects or desiring instructions of one kind or another, in the ordinary administrative duties, and in directing the

work of special agents. During the past year no less than three thousand seven hundred letters have been written to correspondents in answer to inquiries, while nearly one thousand others have been answered by circulars.

A very large number of additions have been made to the collections, and biologic notes have been made upon two hundred additional species not represented before, each number representing a longer or shorter series of notes with records concerning the different states of the insect and observations made at the office or in the field. The amount of pure museum work done in connection with the National Museum has greatly increased since the organization of the experiment stations under the Hatch bill, and, with the impetus given to applied entomology by the consequent organization of entomological research in so many of the States, this branch of the Division work will necessarily augment. The work of determining material sent in for name is all-important in the benefit it confers, though showing little in results at the Department as compared with the time required. Every year adds to the value of the national collection therefor, and I conceive it to be one of the most important functions of the Division to co-operate with other workers in this as in other directions.

The impetus above referred to has found tangible form in the organization of a National Association of Economic Entomologists, which recently held a very successful meeting at Washington, the proceedings of which are published, by request, in INSECT LIFE, Vol. II, No. 6.

The actual publications of the Division during the year have been as follows:

Insect Life:

Volume 1, No. 7, issued January 21; No. 8, issued February 21; No. 9, issued April 10; No. 10, issued April 29; No. 11, issued May 27; No. 12, issued July 2.

Volume 2, No. 1, issued July 20; No. 2, issued August 30; No. 3, issued September 21; No. 4, issued November 2; No. 5, issued December 5.

Bulletin No. 20, "The Root-knot Disease of the Peach, Orange, and other plants in Florida, due to the work of Anguillula," by J. C. Neal, Ph. D., M. D., issued Nov. 1.

The Bibliography of the more important writings of American Economic Entomology, Parts 1, 2, and 3; daily expected from the press.

The fifth and final report of the U. S. Entomological Commission, being a report on Forest Insects, by A. S. Packard, is now going through the press.

The work of the agents of the division is summarized at the close of this report, and in accordance with your instructions. The result has been to restrict the account of it to a mere indication or announcement of some of the results obtained, necessarily of little scientific value compared with the more detailed reports.

The chief investigations of the year summed up in this report, are:

(1) The colonization and spread of the imported enemies of the Fluted Scale (*Icerya purchasi*), in California.

(2) Preliminary investigation of the Leaf-mite of the Orange.

(3) An investigation of the habits of, and remedies for, the Horn Fly (*Hæmatobia serrata*).

(4) A partial investigation of the extraordinary outbreak of the Grain Plant Louse (*Siphonophora avenæ*) in several of the Western States.

An investigation was made of an outbreak of the Lesser Migratory Locusts in New Hampshire, in the same locality as that treated of in

my report for 1883. The result of this investigation was published in full in the September number of INSECT LIFE.

Considerable attention has also been given to perfecting the records of appearance of Brood VIII of the periodical Cicada, which appeared during the year, and more accurate limitations of the territory occupied by it have resulted.

The occurrence of the Buffalo Gnat in great numbers in Louisiana under peculiar circumstances seemed to warrant the sending of an agent to particularly investigate the subject; and his report which has already been published, (INSECT LIFE, Vol. II, No. 1, July, 1889), showed conclusively that the abundance of the gnats in the locality in question was caused by Government operations in diverting a large raft of logs of several acres in extent into Bayou Pierre, a tributary of the Red River, thus furnishing extensive breeding grounds for the gnats.

The work of the Division in investigating the Hop Phorodon, which has been in progress for several years, was completed most satisfactorily early in the present year. A preliminary report was made in my report for 1888.

The mission to Australia has been fraught with such remarkably satisfactory results that I take this occasion to publicly express my acknowledgments to two persons who were most prominent in contributing to its success. A number have thus contributed; but first, Mr. McCoppin, commissioner to the Melbourne Exposition, deserves particular thanks not only for the promptness with which he seconded the suggestion of co-operation, without which the State Department would scarcely have acted, but also for the uniform kindness with which he received and the aid which he gave to the agents of the Division sent out to him. Secondly, all honor is due to Mr. Koebele, on whom the greatest responsibility fell, and whose devotion to the object in view, indefatigable effort, and loyal carrying out of instructions brought success where others would have failed. The success of this experiment has naturally increased the interest in this mode of dealing with injurious insects, and while the circumstances in this case were in some respects peculiar, yet the cases are numerous where similar work will be productive of similar good. I have also desired to return to the Australian fruit-growers the kindness they have shown in helping us, by doing them, if possible, a like service; and hope to send over in the course of time some of the parasites of the Codling moth, some additional species to those already known having been discovered by Mr. Koebele in California the present year.

The work for the immediate future, as partially planned, includes the publication of a number of bulletins already wholly or partly prepared; the completion of the investigation of the Leaf-mite of the Orange; the completion and publication of the report on insecticide machinery; the completion and publication of reports upon the insect enemies of live-stock; the insect enemies of grain and grasses; the final part of the bibliography of economic entomology, etc.

In the Silk Section of the Division the experiments in automatic silk-reeling have been continued in the lines indicated in former reports. Mr. Philip Walker was sent to Europe to fully and carefully study the whole subject of silk culture, especially as it bears upon our own efforts and with a view of ascertaining what progress and improvements have been made abroad.

While in France I also paid particular attention to the question of automatic reeling. Inasmuch as my observations abroad and the

work of the past year have furnished no grounds for changing the opinions clearly expressed by me in my last annual report on this subject, and inasmuch, moreover, as, for that reason, you have concluded to leave to others the future conduct of the silk experiments, relieving me of any further responsibility therefor, I abstain from any reference to the subject in the present report.

Much of my time and thought have been given during the year to the exhibit of our agricultural products at the Paris Exposition. The success thereof has already been announced by you in a notice sent to the press with a list of awards, and it suffices here to add that since that statement I have received a supplementary list, so that the agricultural exhibit, included in fifteen classes, received seven grand prizes, forty gold, sixty-eight silver, and fifty-four bronze medals, and thirty-nine honorable mentions. This is a larger relative percentage of medals than was awarded to the United States in the other seventy-one classes and a very much larger percentage of awards in the agricultural groups as compared with those obtained by the United States either at the Paris Exposition of 1867 or of 1878. In the special class of "Beneficial and Injurious Insects" only three grand prizes were awarded in all, two of which were to the United States and one to Japan.

The Divisional force remains essentially the same as it was a year ago, and while each and all deserve my thanks for the manner in which they have performed their several duties, I feel that I shall not be invidious in specially expressing my acknowledgment to my first assistant, Mr. Howard, who, owing to my long absence in Paris, has had more than the usual responsibility.

Respectfully submitted, December 31st, 1889.

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

THE FLUTED SCALE.

(*Icerya purchasi* Maskell.)

Order HOMOPTERA; family COCCIDÆ.

[Plate III.]

In our last annual report we gave an account of all recent observations upon this insect and brought the investigation down to January, 1889. Few additional points have been learned the present year, and the great practical success of the importation of the Australian insect enemies of the Scale has so relieved the minds of the citrus growers of the Pacific coast that little attention has been paid by them to the subject of washes and gas treatment. In fact the Fluted or White Scale is practically no longer a factor to be considered in the cultivation of oranges and lemons in California. The history of the introduction of this pest; its spread for upward of twenty years, and the discouragement which resulted; the numerous experiments which were made to overcome the insect, and its final reduction to unimportant numbers by means of an apparently insignificant

little beetle imported for the purpose from Australia, will always remain one of the most interesting stories in the records of practical entomology.

We may hardly hope, however, that the last chapter in the story is written. On the contrary, it is more than probable, and in fact we strongly anticipate, that the Icerya will partially recuperate; that the Vedalia will, after its first victorious spread, gradually decrease for lack of food, and that the remnants of the Fluted Scale will in the interim multiply and spread again. This contest between the plant-feeder and its deadliest enemy will go on with alternate fluctuations in the supremacy of either, varying from year to year according to locality or conditions; but there is no reason to doubt that the Vedalia will continue substantially victorious, and that the power for serious harm, such as the Icerya has done in the past, has been forever destroyed. We have learned, also, that it will always be easy to secure new colonizations of the Vedalia where such may prove necessary, or even new importations should these become desirable.

We shall give in this connection simply a summary of the closing phases of the interesting experiment, with such other facts as are worthy of being placed upon record.

IMPORTATION OF THE AUSTRALIAN INSECT ENEMIES.

In our report for 1888 we showed how Mr. Koebele was sent to Australia in August and gave an account of his early sendings of insect enemies, recording how his first shipment arrived in excellent condition and containing a very large number of healthy living specimens of the Dipterous parasite which at that time was known by the name of *Lestophonus iceryæ*, together with ladybirds and lace-wing flies. We also showed how the ladybird larvæ attacked the first Iceryas which they met upon being liberated from the packages. The next shipment, as we there indicated, was not so successful, some of the boxes having been smashed by the falling of ice in the ice-house on the steamer, and the contents of others molding. In January another small lot containing fifty Lestophoni and forty-eight Vedalias together with a few other insects was received. It was in the December shipment that a secondary parasite of the Lestophonus was found. Late in February Mr. Koebele left Australia and spent a large part of the month of March in New Zealand, pursuing there the same quest. Before leaving Australia he sent another quantity of Lestophonus and a large number of Ladybirds of four different species, all of which were alive upon arrival in Los Angeles. The Ladybirds made themselves perfectly at home and began at once to feed upon Icerya. In New Zealand he was unable to find any true parasites, with the possible exception of a single small two-winged fly, but he collected a large number of Ladybirds, among them the same species of Vedalia which he had previously found in Australia. Many of these were brought with him on his return to California in April.

The parasites had been received in California by Mr. Coquillett, and after the disastrous second shipment, which was further delayed in the custom-house in San Francisco, the Secretary of the Treasury, at our request, kindly issued an order to the collector of the port to allow the subsequent packages entry free of duty and to forward them at once to Mr. Coquillett. The manner in which Mr. Coquillett disposed of the Lestophonus was mentioned in our last report,

and we there figured on Plate VIII the tent under which he endeavored to colonize them. Concerning his experience with the Vedalia and the details of its early distribution we have given an account in No. 3, Vol. II, INSECT LIFE, and as this bulletin reaches but a small share of the readers of this annual report we may briefly state that as fast as the ladybirds were received they were placed under a tent on an Icerya-infested orange tree at Los Angeles. Here they were allowed to breed unmolested, and early in April it was found that nearly all of the Iceryas on the tree had been destroyed. Accordingly, one side of the tent was removed and the Ladybirds were allowed to spread to the adjoining trees. At this time Mr. Coquillett began sending out colonies to various parts of the State with the assistance of Mr. J. W. Wolfskill and Mr. Alex. Craw, and by the 12th of June ten thousand five hundred and fifty-five specimens had been distributed to two hundred and eight different orchardists. This was the course taken with the first three consignments, one hundred and twenty-nine specimens in all. The last two consignments, numbering one hundred and eighty-five, were colonized in the groves of Col. J. R. Dobbins, in San Gabriel, and Messrs. A. B. and A. Scott Chapman, in the San Gabriel Valley; Mr. Dobbins receiving eighty-five and the Chapmans one hundred. Mr. Coquillett, writing in August last, said of the distributions made by himself, Mr. Wolfskill, and Mr. Craw from the Los Angeles colony, that in nearly every instance of the two hundred and eight the colonizing of the ladybirds on infested trees in the open air proved successful. The orange and other trees, about seventy-five in number, and also the shrubs and plants growing in Mr. Wolfskill's yard, had been practically cleared of Icerya by the ladybirds, and the latter had of their own accord spread to the adjoining trees for a distance of three-quarters of a mile from the original tree. That, as we have said, was in August.

Concerning the later colonizations, Colonel Dobbins and the Messrs. Chapman have themselves reported. Colonel Dobbins, writing as early as July 2, made use of the following language:

> The Vedalia has multiplied in numbers and spread so rapidly that every one of my thirty-two hundred orchard trees is literally swarming with them. All of my ornamental trees, shrubs, and vines which were infested with White Scale are practically cleansed by this wonderful parasite. About one month since I made a public statement that my orchard would be free from "Icerya by November 1," but the work has gone on with such amazing speed and thoroughness that I am to-day confident that the pest will have been exterminated from my trees by the middle of August. People are coming here daily, and by placing infested branches upon the ground beneath my trees for two hours can secure colonies of thousands of the Vedalia, which are there in countless numbers seeking food. Over fifty thousand have been taken away to other orchards during the present week, and there are millions still remaining, and I have distributed a total of sixty-three thousand since June 1. I have a list of one hundred and thirty names of persons who have taken the colonies, and as they have been placed in orchards extending from South Pasadena to Azusa, over a belt of country 10 miles long and 6 or 7 in width, I feel positive from my own experience that the entire valley will be practically free from Icerya before the advent of the new year. You will be as much pleased to read this as I am to write it.

October 22, Colonel Dobbins wrote further as follows:

> * * * The Vedalia had practically freed my orchard of Iceryas on the 31st of July. It was on that date that I was obliged to post a notice at the entrance to my place saying that I had no more Vedalias for distribution. The Scale and Ladybird had fought out the battle, and while the carcasses of the vanquished were everywhere present to tell of the slaughter, the victors had disappeared almost entirely from the field. I have 35 acres in orchard—some three thousand two hundred trees in all. I never colonized any Vedalias in my grove, excepting the two consign-

ments which you brought to me yourself—one box on February 22 and two boxes March 20. I noticed the first increase from lot No. 1 on the 15th of April, and from lot No. 2 on the 24th of the same month. On the 25th of April I found larvæ upon several adjacent trees. These facts are from memoranda made at the time. I have a list of the names of fruit-growers, two hundred and twenty-six in number, to whom I personally distributed over one hundred and twenty thousand Vedalias in colonies of various sizes between May 31 and July 31.

Mr. A. Scott Chapman describes the result of the colonization upon his own place and that of his father in a letter dated October 18th, as follows:

* * * The Vedalias that you brought to my place about the 20th of last March, and which we colonized on four large orange trees that were covered with Fluted Scale, have spread in all directions, although, to begin with, they followed the direction of the wind most readily. From those four trees they have multiplied so rapidly that in my orchard of three thousand trees it is seldom that we can now find a Fluted Scale. I find a few of them on some weeds in spots, but I can also find the beetles there. The trees have put on a new growth and look altogether different; even the black fungus on the old leaves has loosened its hold and begins to fall to the ground. Besides having cleaned my orchard they spread also to the orchard of my cousin and to my father's orchard; the latter was also re-enforced by colonies from Mr. J. W. Wolfskill and from Col. J. R. Dobbins. As my father has some ten thousand trees, and most all were more or less infested, the Vedalias had a grand feast ahead of them, and they have done their work most wonderfully. What I have said of my orchard applies to my father's also, and really to all our neighbors. When the Vedalias first began to multiply we took colonies of fifty or more in the pupa state and placed them in different portions of the orchard, and even had we not done so the Vedalia unaided would itself have reached there in almost the same time.

On the Chapman place the Vedalias have cleaned the Fluted Scales off of the 150 acres of land. They have taken more than an oppressive burden off of the orange-grower's hands, and I for one very much thank the Division of Entomology for the *Vedalia cardinalis*, the insect that has worked a miracle.

In August Prof. W. A. Henry, director of the Wisconsin Agricultural Experiment Station, visited California in the interest of the Department of Agriculture and made personal observations upon the result of this importation of the Vedalia. His account we quote in brief:

In studying this insect we first visited the place of Mr. William Niles, in Los Angeles, where the "Ladybird" (*Vedalia cardinalis*) was being propagated by the county insect commission for dissemination among the orange groves infested with the Cottony Cushion, or White Scale. We found five orange trees, standing about 18 feet high, inclosed by walls of cheap muslin supported by a light frame-work of wood. The orange trees inside this canvas covering had originally been covered with the White Scale, but the Vedalia which had been placed on these trees were rapidly consuming the last of the pests. Entering one of these canvas houses we found the Vedalia, both larvæ and adults, busy consuming the Scale; here and there on the canvas were the beetles endeavoring to escape to other trees. These insectaries were in charge of Mr. Kircheval, one of the county insect commissioners, who kept a record of the distribution of the beetle. It was indeed a most interesting sight to see the people come—singly and in groups—with pill boxes, spool-cotton boxes, or some sort of receptacle, in which to place the Vedalias. On application they were allowed within the insectaries, and each was permitted to help himself to the beetles, which were placed in the boxes and carried away to be placed on trees and vines infested with the White Scale at their homes. Mr. Kircheval kept a record of the parties and the number of beetles carried off. The number coming for the Vedalia was surprisingly large—scores in a day—and each secured at least a few of the helpful beetles. That the supply should hold out under such a drain was a great surprise, and speaks better than words of the rapidity with which the Vedalia multiplies when there are Scale insects enough to nurture the young.

We visited other points—Lamanda Park, Santa Anita, Sierra Madre Villa, Pasadena, etc. At the time of our visit to Sierra Madre Villa, August 23, the White Scale had already disappeared before the Vedalia. At Santa Anita, the ranch of Mr. E. J. Baldwin, we examined a 350-acre orange orchard, in which the White Scale had started a most destructive course. Mr. Baldwin began an equally vigor-

ous defense, going personally into the orchard and superintending the work of fighting the White Scale. There was every sign, however, that the Scale was going to be the victor. Some of the trees were almost ruined by the severity of the application made. Happily, before the pest had gone far in its work, the Vedalia was heard from, and Mr. Baldwin secured a number, which were placed in the hands of one man specially detailed to look after its welfare. This individual spent six weeks in colonizing the Vedalia in various parts of the orchard. After that time a careful examination showed the superintendent that the work of colonizing was so complete that further effort in that line was unprofitable. It was predicted at the time of our visit that a few weeks more would leave the orchard entirely free from the White Scale. At Chapman's we found the citrus orchard, formerly so famous, entering the death stages from the White Scale, which was now fortunately being so effectually checked. At Pasadena, on the grounds of Prof. Ezra Carr, we found that some of the shrubbery had been seriously injured by the White Scale, but thanks to the Vedalia not a single pest was alive at the time of our visit. Mrs. Jennie Carr pronounced the Vedalia "a miracle in entomology."

A word in relation to the grand work of the Department in the introduction of this one predaceous insect. Without doubt it is the best stroke ever made by the Agricultural Department at Washington. Doubtless other efforts have been productive of greater good, but they were of such character that the people could not clearly see and appreciate the benefits, so that the Department did not receive the credit it deserved. Here is the finest illustration possible of the value of the Department to give people aid in time of distress. And the distress was very great indeed. Of all scale pests the White Scale seems the most difficult to cope with, and had no remedy been found it would probably have destroyed the citrus industry of the State, for its spreading to every grove would probably be only a matter of time. It was the Department of Agriculture at Washington which introduced the Washington Navel Orange into South California, and the Department has now given an effective remedy for the worst scale insect. The people will not soon forget these beneficial acts.

We have quoted these statements of Colonel Dobbins, Mr. Chapman, and Professor Henry for the reason that they are made by eyewitnesses both interested and uninterested and afford a more perfect idea of the good accomplished than anything we can say. The rapidity with which the Vedalia has multiplied and the voracity which it has shown have cast nearly into the shade the other insect enemies brought over at the same time. The Dipterous parasite, of which we expected much, proves to be a very slow breeder and not to adapt itself readily to the California surroundings. The same may be said of the other insects brought over alive. A very promising predaceous caterpillar (larva of *Thalpochares cocciphaga* Meyrick, Plate III, Fig. 6) was unfortunately lost, partly through the very success of the Vedalia. Several of the other ladybirds, nearly all of the Scymnid group, were observed to feed, but were soon lost sight of. They may possibly increase and yet be found acclimated.

ADDITIONAL POINTS BROUGHT OUT THIS SEASON.

We may briefly summarize a few other matters connected with Icerya.

Gas Treatment.—We mentioned in our last annual report a patent scheme for one of the fumigating processes, and stated that from information which we had received from the Patent Office no patent had been issued and that on account of the so-called Hatch patent having expired no letters patent can be issued for the process. Another claim to a patent has recently been made in California and in reference to it we need only repeat our statement of a year ago. As indicated in this report under the head of "Work of field agents," Mr. Coquillett has been experimenting with a view of finding a cheaper method of using the hydrocyanic gas. He has succeeded in reducing the expense to one-third that necessitated by the former

method, while much of the cumbersome machinery described in our report for 1887 has been found unnecessary.

Native Parasites.—Of the native parasites mentioned in our last report, three, namely, *Encyrtus dubius*, *Coccophagus californicus*, and *Thoron opacus* were described by Mr. Howard in the February number of INSECT LIFE. The others we hope soon to describe under the names already given. A new enemy has been recorded by Mr. Coquillett in the August (1889) number of INSECT LIFE, page 49, in the shape of a long, slender, brownish soldier beetle, *Telephorus consors*, which feeds upon the eggs of Icerya after first tearing off the cottony covering.

Mr. Webster's Trip to Australia.—Our Indiana agent, Mr. F. M. Webster, went to Australia on the December (1888) steamer, returning to this country in April. We sent him primarily to make a report on the agricultural aspects of the Melbourne Exposition, in accordance with our arrangement with the State Department, but he also assisted Mr. Koebele somewhat in his work. A report by Mr. Webster upon some Tasmanian insects may be found in the June number of INSECT LIFE, pages 361 to 364.

An Application to prevent Icerya from ascending Trees.—Mr. Coquillett reported in April that he had been experimenting in this line, and found that an application prepared of 4 ounces of resin, 1 ounce of beeswax, and 5 fluid ounces of cotton-seed oil melted and stirred together and spread upon the trunk of the tree will remain moist for over a week. He advises the use of this application where the trees have been washed with cold water, as a means of preventing the scale insects from climbing back upon the same tree.

Further Importations.—From the present outlook no further importation of Vedalia will be necessary. In May the fruit-growers of California petitioned the Department to send another qualified agent, and the entire matter is well summarized in a letter written by the Hon. Edwin Willits, Assistant Secretary of Agriculture, to the Hon. Ellwood Cooper, president of the State board of horticulture, and which is published in the July number of INSECT LIFE. The letter details the exact position in which the Department is placed. The Department has now correspondents in Australia so well qualified and so extremely obliging that it is quite likely that future invoices may be received without the necessity of sending an agent to that country.

New Food-plant of Icerya.—Mr. Coquillett wrote in May that he had for the first time found the Icerya to infest a conifer. A Cedar of Lebanon (*Cedrus libani*) growing in a door-yard in Los Angeles was found covered with the insect in all stages. This is the first record of its infesting a conifer in California, although in New Zealand it has been found upon pines, firs, and spruce.

A Florida Icerya Scare.—The Florida newspapers on a number of different occasions during the early part of the season published statements to the effect that the Icerya had been found in Florida. A number of these cases were investigated by correspondence and either the common Mealy Bug or the Florida Wax-scale was found in every case to have originated the rumor. *Icerya purchasi* has not been found in any of the Eastern States, although its appearance on the Atlantic coast is possible at any moment. We pointed out the danger, in our report for 1886 and in other writings, and Florida orange-growers should adopt concerted means to prevent such a misfortune by the most stringent examination and disinfection of

plants and cuttings from southern California, Australia, New Zealand and South Africa.

Concerning the Lestophonus.—The genus which Dr. Williston erected for the first found of the Australian natural enemies of Icerya proves to be a synonym, and the insect should be known as *Cryptochætum iceryæ* (Williston). After an examination of the material in the Department collection made by Dr. Williston during April last, he was tolerably certain that the specimens of this parasite reared from Icerya were identical with specimens reared from another large scale insect in Australia named *Monophlœbus crawfordi*, and his statement to this effect is published in the May number of INSECT LIFE. His conclusions have been criticised by Mr. F. A. A. Skuse, of Australia, and recent examinations which we have made with more extended material prove that Mr. Skuse is correct and that the species infesting Monophlœbus is a different species, as species go, from that infesting Icerya. Both species, however, seem to breed indiscriminately upon both Icerya and Monophlœbus, so that Mr. Koebele's sendings of infested Monophlœbus were as valuable as anticipated.

The Vedalia confined for Food to Icerya.—The feeding habits of the Vedalia seem to be very uniform, and up to the present time it has not been noticed to feed upon any other scale insect than the one for whose destruction it was brought over. We at one time feared that it might breed upon the Cochineal insect, in which case its spread into Mexico might have proved unwelcome; but we learn from Mr. R. Allan Wight, of New Zealand, that in that colony the Vedalia does not feed upon *Coccus cacti*.

A new primary Hymenopterous Parasite in Australia.—Just as we are sending in this report we have received from Mr. Crawford a series of a new primary parasite which he reared from a number of Iceryas received from a place 50 miles south of Adelaide. Mr. Crawford writes us that the proprietor of the grove had never seen anything of the kind and sent them to him for determination. Upon examination they prove to belong to a new genus somewhat closely allied to *Dilophogaster* Howard, the only species of which is a very valuable parasite of the Black Scale in California. This new genus we have called *Ophelosia*, naming the species after Mr. Crawford, in testimony of his great interest in the matter and of our high appreciation of his labors. (See INSECT LIFE, Vol. II, Nos. 7 and 8, p. 248.)

THE SIX-SPOTTED MITE OF THE ORANGE.

(*Tetranychus 6-maculatus* Riley.)

Order ACARINA; family TETRANYCHIDÆ.

[Plate II.]

Since 1886 no pest has caused more uneasiness and alarm among the orange-growers of Florida than the one now generally known by the above name. Our correspondents have also referred to it, however, as the "Leaf-mite," the "Spider," the "California Spider," the "Red-spotted Mite," and the "Red Spider." This pest first made its appearance in numbers in 1886, being especially abundant at that

time in groves at Maitland and Orlando. Its appearance immediately after the severe freeze of 1885–'86 led to the very general belief, which is probably well founded, that the trees, weakened by the cold of that winter, were unable to resist or sustain the attacks of the mites, thus enabling the latter to multiply prodigiously.

We are at present unable to decide whether this mite is an indigenous species or a comparatively recent introduction. The former supposition seems, from the facts at hand, the more probable.

Whatever its origin, its appearance in injurious numbers practically dates from the spring of 1886. With the rainy season, June and July, of that year, the mites entirely disappeared. They again appeared during the dry season, March to June, 1887, in even greater numbers and over a wider territory, extending their attacks over almost the entire orange belt of the State. The drought of that year was unusually severe and the mites increased enormously, but were again destroyed by the midsummer rains. During the year 1888 its appearance was not so marked, but it was very generally reported, and in many places was as injurious as in either of the two preceding years.

The long and severe drought of the present year, during which in many places seven weeks passed without rain, again afforded the best possible conditions for the abundant increase of the mite, and there is no doubt but that it was more wide-spread and destructive than in former years.

Since the appearance of the Six-spotted Mite of the Orange in 1886, the Florida press has made frequent reference to it, both editorially and through correspondence. Several of the articles, and especially those of a former agent of the Division, Mr. H. G. Hubbard, of Crescent City, Fla., were of a practical nature, describing the work of the mite, and giving measures of value against it.*

During the past four years the Division has received, especially during the months of April, May, and June, a large number of letters inquiring about this pest, all of which have been answered at length, giving both the history of the mite and the best means against it.

On its re-appearance in the spring of 1889 the Department was again urged by orange-growers, and particularly by Senator Pasco, to send an agent to Florida to study its habits and to experiment with remedies. At that time, however, we were unable to carry out the suggestion, and it was determined to draw up a preliminary report, and at some future time, if found desirable, to make a fuller field study of the subject. Letters were therefore sent out to a large number of orange-growers of Florida, in which the full history and habits of the mite were given as far as known, and also the various measures against it that had been used or recommended. Request was made that these remedies or others be tested, and also that we be informed of any new facts relating to the habits or remedies that might come under notice.

The responses have been very satisfactory and have been used in the preparation of this article. Mr. Ashmead, an agent of the Division, was in Florida in July, and was directed to make investigations relating principally to the disappearance of the mites with the rainy season.

---

* See articles by Mr. Hubbard in the *Florida Dispatch*, May 14, 1886, and July 25, 1887, and by Mrs. L. B. Robinson, in *The Home and Farm*, July 15, 1886.

FOOD-PLANTS.

The original food-plant of this mite is still uncertain. It was first noticed on the Wild or Sour Orange. It soon attacked the Sweet Orange, and the damage was much greater than in the case of the wild trees. Later the lemon and citrus trees generally were infested.

DESCRIPTION AND LIFE HISTORY.

The natural position of this mite is with the Spinning Mites (*Tetranychidæ*), of which the Red Spider (*T. telarius*) of hot-houses is a familiar example. These mites have the habit of congregating on the leaves of various plants, especially on the lower side along the principal veins, where they spin their delicate, scarcely perceptible, webs. Under the protection of these webs they feed on the juices of the leaf extracted through abrasions in the epidermis, causing the leaves to become pale and spotted, and finally to shrivel and fall.

The species under consideration when full-grown is about 0.3 millimeter long, oval in shape, being widest just back of the eyes. The general color is pale greenish-yellow; the abdomen is marked above with six or less small dusky spots, which are arranged in two subdorsal rows of three spots each. These markings are quite constant, especially in the smaller and more numerous specimens, though somewhat variable in the larger mites.

The young mite differs from the adult in size, and in being either without markings or in having the middle pair wanting; also in having but three pairs of feet.

The eggs, which are loosely attached to the web, are globular, very minute, but large in proportion to the size of the adult mite, and are either colorless or very pale greenish-yellow.

With warm and dry weather the period from the egg to the adult is certainly short, probably not exceeding ten days.

MEANS OF DISPERSION.

This mite may be carried from tree to tree or from grove to grove as are the scale pests of the Orange or the rust mites, the various means of dispersion of which are discussed at length in Hubbard's "Insects Affecting the Orange." They are doubtless transported on leaves, fruit, and nursery stock; and more commonly, perhaps, by attaching themselves to birds and insects. The rate of progression of the mites is about 2 inches to the minute or 10 feet to the hour, a speed sufficient to enable them, unaided, to overrun a grove in a single season.

EFFECT OF ITS ATTACK.

The first indication of the work of this mite is the yellowing of the leaves, which on the upper surface shows as a line of streaks and spots along either side of the midrib (Plate II, Fig. 2). The under surface (Plate II, Fig. 1) becomes soiled by the accumulated excrements in the form of minute black spots and by the webs and cast skins of the mites. Later the leaves curl or shrivel and finally fall, leaving the tree nearly bare, and in severe cases the limbs are killed back several inches. The general estimate of our correspondents is that badly infested trees lose one-half or more of their leaves,

and from one-third to two-thirds of the half-grown fruit. The falling, especially of the latter, is also charged to the drought. A single instance of the shrinkage in the yield of oranges from this cause may be given. Mr. A. S. Kells, manager of the Crescent Orange Grove Company, of Citra, Fla., writes June 10, 1889:

From this grove we shipped 24,000 boxes of oranges during the past season, whereas this season we only expect about 9,000 or 10,000 boxes, although the trees were never so laden with bloom as in the spring of 1889.

TIME OF APPEARANCE; EFFECTS OF CLIMATE AND SOIL.

The yearly injuries occasioned by the mites, and hence the mites themselves, begin to be noticed in the latter part of February or first of March, and the severity and duration of their attacks are dependent on the dry season, which prevails to a greater or less degree from February or March to the middle of May or the first of June. The rainy season of four to six weeks' duration in June and July so reduces their numbers that they escape the further notice of the orange-growers, who very generally report that they entirely disappear. We have reports, however, from one or two intelligent observers of the occurrence of both eggs and mites on the trees in August and September. That the disappearance of the mites is almost complete is still further shown by the investigation of Mr. Ashmead already alluded to. After examining in July a number of groves that had been severely infested earlier in the season, he was able to find living mites in but one instance, and then only in limited numbers. We have little direct evidence, therefore, that the mites breed on the orange trees from July to February, but until evidence to the contrary is produced it is safe to assume that some few survive the rains, and by reason of their limited numbers and the new and vigorous growth of foliage following the rains they do no appreciable damage and are not noticed.

Rapid increase is prevented from July to September by frequent showers, and from October to February by rains and cold. The latter period may either be passed by the adult in a dormant condition under bark or other protection near at hand, or by the eggs, as is the case with certain allied species the habits of which are known.

It has been abundantly proved that vigorous trees are comparatively free from the attacks of the mites. This is shown in that serious injury is only done in the time of drought; that young growing trees are little affected; that the hardy Wild Orange is much less subject to attacks than the sweet varieties; and that trees grown on low moist land, or where irrigation or artificial watering is practiced, are likewise exempt.

Trees grown on "high hammock land," which is rich in the elements of plant food, are not injured to any extent. The "pine or sandy land," on which ninety-nine one-hundredths of the oranges are grown, and on which artificial fertilizers must be constantly employed, suffer most both from the drought and the mite.

EFFECT OF CLEAN AND CAREFUL CULTURE.

Mr. Charles F. Parker, of Gabriella, Orange County, writes that by clean culture he was able to keep his grove comparatively free

from the mites and to secure large yields of fruit. In this connection he says, in letter of December 30, 1887:

I did what I thought common sense suggested, viz, at once set about cow-penning* and well working that portion of the grove. * * * The result, whether of the treatment or of natural causes, was that this year (1887) these trees have all borne heavily, and I have seen scarcely one of the pests in any part of the grove of one thousand trees.

Mr. Andrew Hamman, of Fort Mason, Lake County, in letter of June 13, 1889, states that the grove of which he has charge, Mr. J. M. Bryan's, suffered less than one-fourth as much from the mite and drought as others in the neighborhood, because, as he writes, it was kept thoroughly cultivated and clean.

REMEDIES.

The fact that the midsummer rains effectually destroy the mites has led to a very general neglect of measures that could be used with good results earlier in the season, and orange-growers as a rule have relied on the possibility of timely rains instead of instituting energetic and preventive work against this pest. A number of trials with insecticides have been made, however, and the following accounts have been received, for the most part in answer to our request for such reports, already referred to. Others have appeared in Florida papers. Both in the case of the letters and the published accounts, we have quoted the language of the writers.

The principal insecticides employed have been the kerosene emulsions, to which powdered sulphur has commonly been added, whale-oil soap and sulphur, and the Eureka Insecticide, a preparation of sulphur and lime intended especially for the Orange Rust-mite, manufactured by E. Bean, Jacksonville, Fla. All the insecticides named have given fairly good satisfaction. The use of whale-oil soap and sulphur is recorded in experiments Nos. 1 and 2; of kerosene emulsion and sulphur in Nos. 3 to 6; of the Bean Insecticide in No. 7. Applications of pure water have been followed with good results, as shown in experiments 8 and 9.

It is worthy of note that sulphur, the well-known specific against the Orange Rust-mite is also a valuable means against the Six-spotted Mite of the Orange, so that the same application that prevents the rusting of the orange by the former mite will keep the latter in check.

EXPERIMENTS WITH INSECTICIDES.

No. 1.—*Whale-oil Soap and Sulphur.*—"The remedy is sulphur, which is best applied with some viscid liquid in the form of spray. Whale-oil soap solution is an excellent medium in which to apply the sulphur, as it is itself a powerful insecticide, and moreover causes the sulphur contained in the solution to adhere to the leaves. The eggs of the mite are not killed by the mixture, but the sulphur remaining on the leaves will kill the mites as they hatch. The whale-oil soap solution should not be less than one-quarter of a pound of soap to 1 gallon of water. One pound of sulphur will suffice for 5 gallons of the liquid."—(H. G. Hubbard, in *Florida Dispatch*, July 25, 1887.)

No. 2.—"The most effective wash I have known to be tried here is a mixture of whale-oil soap, 7 pounds, and 1 quart of sulphur by measure to 1 barrel of 40 gallons of water.

"This applied in a fine spray destroys all the living mites and leaves a deposit of sulphur on the leaves, which destroys the young mites as they hatch."—(A. S. Kells, Citra, Marion County, Fla., June 11, 1889.)

No. 3.—*Kerosene Emulsion and Sulphur.*—"Kerosene emulsion, with 2 or 3 ounces of dry sulphur added to each gallon of the wash, may be used as a remedy. A strong solution of whale-oil soap with sulphur will also be effective. Sulphurated lime,

---

* Fencing groves and feeding cattle in them.

made by boiling together one part of sulphur, two parts of lime, and ten parts water, will undoubtedly kill the mites, but will not be likely to destroy the eggs. Whatever remedy is used, two or three applications will be needed, owing to the impossibility of exterminating the eggs. The applications should be made at intervals not exceeding one week; five days will be safer if the weather is warm."—(H. G. Hubbard, *Florida Dispatch*, May 17, 1886.)

No. 4.—"Used Hubbard's kerosene emulsion with addition of 3 ounces of sulphur to each gallon of the mixture, applying with a small hand-pump. Pump was so small that I could not do much, but I am satisfied that the mixture killed the mites whenever it came in contact with them. Had no glass with which to observe the effect on the eggs, and in a few days the mites were back again, whether from eggs or from other trees I could not be sure, and I am satisfied that had they all been killed on any tree they would soon have returned from other trees."—(Charles G. Wilson, Rose Hill, Fla., June 10, 1889.)

No. 5.—"I used (1886) the kerosene and whale-oil soap emulsion, with the result that it diminished their numbers, although it did not exterminate the pest."—(Charles F. Parker, Gabriella, Orange County, Fla., June 10, 1889.)

No. 6.—"While upon this subject it may interest you to know that I followed your instructions, spraying the trees with kerosene and whale-oil emulsion, always near sundown, and doing this thoroughly. Only partial success."—(Charles F. Parker, December 30, 1887.)

No. 7.—*Bean's Eureka Insecticide.*—"Last year we sprayed our trees for the rust-mite with Mr. Bean's preparation of lime and sulphur. We have been over the grove once this year and now again, and can see that we are helping the trees; but it is very hard to kill all the insects. We expect to continue going over the trees, and thus keep the fruit bright, as well as get rid of the spider. By means of a horse-cart, the driver pumping to supply the nozzles, two rows of trees are sprayed at a time. By having another man to pump the water, mix it, etc., we get out say 10,000 to 12,000 gallons per day, spraying four or five hundred large bearing trees. It is a tedious, expensive job, but a profitable one, nevertheless."—(F. G. Sampson, Boardman, Fla., May 28, 1889.)

No. 8.—*Water as an Insecticide.*—"I find that spraying a tree with water will rid it of these pests by causing them to fall to the ground, where they are effectually destroyed by the dripping from the trees."—(A. S. Kells, Citra, Fla., June 11, 1889.)

No. 9.—"By request of L. B. Wombwell, esq., I inform you that the orange leaf-mite (red spider) made frequent incursions into my grove at Montverde during the months of April and May last, but invariably disappeared upon the application of copious showers of lake water from a 2½-inch hose under a pressure of 165 pounds. The water was thrown in a stream 100 feet into the air and fell as a heavy rain. Ordinarily the whole surface of the land was watered once in five or seven days, the frequency depending upon the evaporation caused by the wind. Twice only was water applied to drive out the insect when not necessary to the land. * * * As this irrigation to wet trees and land costs, exclusive of plant, only 25 cents per acre per application, it seems to me a cheaper method than by the use of insecticides. In my grove an occasional affected leaf could be found. In neighboring groves, not irrigated, more leaves were on the ground than on the trees when I last saw them, about June 1."—(James Franklin, Montverde, Fla., July 11, 1889.)

THE HORN FLY.

(*Hæmatobia serrata* Robineau-Desvoidy.)

Order DIPTERA; family MUSCIDÆ.

[Plates IV and V.]

We have already published (INSECT LIFE, Vol. II, No. 4, October, 1889, pp. 92–103) a somewhat complete account of the life history of this insect, together with recommendations as to remedies, from which we may condense the more important information, mentioning also one or two additional points.

FIRST APPEARANCE, SPREAD, AND INVESTIGATION.

We first learned of this pest in September, 1887, through Mr. I. W. Nicholson, of Camden, N. J. In the spring of 1888 the same gentle-

man again wrote to us about it, and we heard of it also in Maryland. In 1889 it was found in many localities in Maryland and through Virginia south to Bedford County. The latter part of August it was found for the first time in the vicinity of Washington. It was carefully studied through the summer, mainly by our first assistant, Mr. Howard, and by Mr. Marlatt. It is probably an importation. The insect first appeared in the neighborhood of Philadelphia and gradually spread southward. It is unquestionably identical with the European species *Hœmatobia serrata* previously found in southern France. The exact time and place of its importation has not been traced, but the probabilities are that it came over with European cattle about 1886, imported through the quarantine station of this Department at Garfield, N. J.

POPULAR NAMES AND ERRORS.

The name "Horn Fly" has been quite generally adopted, and has reference to the habit which the flies have, particularly early in the season, of settling in large numbers around the base of the horns. It has also been called the "Texas Fly," the "Buffalo Fly," and the "Buffalo Gnat." These names indicate erroneous popular impressions that the insect came from the West.

It is an error to suppose that the fly damages the horn, yet this has been often stated in the newspapers during the past season. Some persons believe that the fly eats into the horn, causes it to rot, and lays eggs in it which hatch into maggots and thus penetrate the brain. There is absolutely no foundation for this opinion.

LIFE HISTORY.

The eggs are deposited during daylight, chiefly between 9 a. m. and 4 p. m., and more particularly during the warmer morning hours. They are laid singly and usually upon their sides upon the surface of wet dung the moment the latter is dropped. So far as known they are laid upon no other substance, and never upon old dung. The larvæ upon hatching descend into the dung, remaining, however, rather near the surface. When full-grown they are about two-fifths of an inch in length and of normal color and form. The puparium is formed in the ground beneath the dung. The time elapsing from the egg to the adult is from ten to seventeen days, averaging, say, two weeks, and there are probably seven or eight generations annually. The winter habits have not been definitely determined, but at this writing (the winter having been exceptionally mild) the species is found in the larva and pupa states. Hibernation doubtless takes place normally, either as an adult around stables or as a puparium below the surface of the ground. The flies make their appearance in May, becoming most abundant in July, and gradually dwindling in this latitude until November or until sharp frosty nights become frequent. The characteristic habit of clustering about the base of the horn is developed only when the flies are quite abundant. When they average only one hundred or so to an animal comparatively few will be found on the horn. Moreover the horn-clustering habit seems to be more predominant early in the season than later. The horns are not the only resting places, as vast numbers cluster also upon the back, between the head and fore shoulders, where they can be reached by neither head nor tail.

In the feeding position the wings are slightly elevated, and are

held out from the body at an angle of 60° from the abdomen; the legs are held out widely, and the beak, inserted beneath the skin of the animal, is held in nearly a perpendicular position. The fly, before inserting its beak, works its way through the hair close to the skin, but it is able, at a fling of the tail or an impatient turn of the head, to rise instantaneously in flight, settling back as quickly. The fly itself may be readily recognized from the figures. It is about one-half the size of the house-fly, which it resembles in general appearance.

AMOUNT OF DAMAGE.

We have seen a newspaper statement from President Alvord, of the Maryland Agricultural College, to the effect that no damage results, according to his observations, from the visitations of the insect, and that the cattle seem indifferent to it even when very numerous. He does not believe that they have caused any real damage or even much annoyance. The only way in which we can explain this extraordinary statement is by supposing that President Alvord has not seen the flies in their customary abundance. Any stock-raiser in Fauquier County, Va., or in some localities in New Jersey, would laugh at such a statement. It is true that the accounts of the damage done have been greatly exaggerated, and we have been unable to substantiate a single reported case of death resulting from the bites of the flies. There can be no question, however, but that, when as numerous as they were last summer, they affect stock injuriously, reducing flesh, while in the case of milch cows the yield of milk is unanimously stated to be reduced from one-fourth to one-half. This is a point on which dairymen can not possibly be mistaken. Col. Robert Beverly, of Fauquier County, was so certain in July that his range steers were being badly reduced in condition that he shipped them off by the car-load. There is, moreover, quite a common belief that the bites will eventually produce sores, and we have seen quite a number of cattle afflicted with large, open wounds, which were attributed to these flies. It seems to us, however, that the flies are only indirectly the cause of such spots. The irritation caused by the bites causes the animals to rub themselves violently and severely against trees and fences, and to constantly lick such points as the neighborhood of the bag and the inside of the hind thighs, which they can not well reach in any other way. The sores are probably brought about in this way.

PREVENTIVE APPLICATIONS.

Almost any greasy substance will keep the flies away for several days. A number of experiments were tried in the field, with the result that train oil, with a little sulphur or carbolic acid added, will keep the flies away for from five to six days, while with a small proportion of carbolic acid it will have a healing effect upon sores which may have been formed. Train oil should not cost more than from 50 to 75 cents per gallon, and a gallon will anoint a number of animals. Common axle grease, costing 10 cents a box, will answer nearly as well, and this substance has been extensively and successfully used by Mr. William Johnson, a large stock dealer at Warrenton, Va. Tallow has also been used to good advantage. The practice of smearing the horns with pine or coal tar simply repels them

from these parts. Train oil or fish oil seems to be more lasting in its effects than any of the other substances used.

APPLICATIONS TO DESTROY THE FLY.

A great deal has been said during the summer concerning the merits of a proprietary substance consisting mainly of tobacco dust and creosote, known as "X O dust," and manufactured by a Baltimore firm, as an application to cattle, and it has received an indorsement from Prof. J. B. Smith, entomologist to the New Jersey Experiment Station. We are convinced that this substance has considerable merit as an insecticide, and know from experience that it will kill many of the flies when it touches them, although they die slowly and a few may recover. The substance costs 25 cents a pound, and is not lasting in its effects. Where it is dusted through the hair the flies on alighting will not remain long enough to bite, but two days later, according to Mr. Howard's observations, they are again present in as great numbers as before. A spray of kerosene emulsion directed upon a cow would kill the flies quite as surely, and would be cheaper, but we do not advise an attempt to reduce the numbers of the pest by actually killing the flies.

HOW TO DESTROY THE EARLY STAGES.

Throwing a spadeful of lime upon a cow-dung will destroy the larvæ which are living in it, and as in almost every pasture there are some one or two spots where the cattle preferably congregate during the heat of the day, the dung which contains most of the larvæ will be all the more easily treated. If the evil should increase, therefore, it will well pay a stock-raiser to start a load of lime through his field occasionally, particularly in May or June, as every larva killed then represents the death of very many flies during August. This course will be found in many cases practical and of great avail, and will often be an advantage to the pasture besides.

Plaster is urged by Professor Smith as better than lime for this purpose, for the reason that it will not destroy the free ammonia in the dung and thus render it less valuable for manure. This point is worthy of consideration, and would be more so if Professor Smith's theory that the flies laid their eggs at night and around the stables and manure pits were correct. He also suggests that the mere spreading out of the fresh dung with a shovel will destroy the larvæ which it contains, for the reason that it will dry up more quickly.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fabr.)

Order HOMOPTERA; family APHIDIDÆ.

[Plates I and VI.]

Since 1861 there has been no such appearance of this insect as occurred last season. For many years it has been present every spring in the wheat-fields, but, although occasionally very numerous and often reported to the Department, has never done serious damage, disappearing at the critical time through some change in the weather, or through the sudden increase of its natural enemies. During the past season, however, instead of disappearing it kept on increasing,

until in many localities its numbers became extraordinary, its natural enemies not gaining the upper hand until nearly harvest time.

PAST DAMAGE.

The year 1861 is the only one in which wide-spread, serious injury has previously been recorded. In that year, in the New England States, New York, northeastern Pennsylvania, and some portions of Canada almost every grain-field was thronged with the lice. Dr. Asa Fitch carefully studied it that year, noticing it for the first time early in May on winter grain, winged individuals beginning to appear toward the close of the month. He noticed at that season that each female gave birth to four young daily, making the offspring of one female in twenty days upwards of 2,000,000. As soon as the heads of grain put forth in June the lice were observed to forsake the other parts of the plant and cluster on the heads, changing from a grass-green color to orange. He evidently did not trace the insect through the season but makes simply the general statement that, on the approach of fall, males are produced and winter eggs are laid, probably on fall-sowed wheat and rye, and that the eggs hatch in spring. He showed that in some instances in 1861 the yield of spring wheat was reduced one-half, and gave an account of such of the species of natural enemies as came under his observation.

In glancing through the bulletins of the Statistical Division of the Department we notice that the lice were reported in numbers during the following years: 1868, Rutherford County, Tenn.; 1869, Green County, Tenn.; 1874, Caroline County, Md.; 1876, Lincoln County, N. C., and Fannin County, Ga.; 1880, Aiken County, N. C., and Halifax County, Va.; 1882, "The Grain Aphis has been numerous in some of the Southern and Middle States;" 1887, "*Siphonophora avenæ* did early and quite general damage to oats throughout this region" (Illinois, Iowa, Wisconsin).

Dr. Cyrus Thomas, in his report as State entomologist of Illinois for 1879, mentioned the occurrence of the Grain Aphis in great numbers in his State in 1866 and 1876, and adds to the facts given by Fitch the finding of winged and wingless specimens upon wheat during the winter of 1875, the wingless below ground and the winged above. He also states that the species works upon Barley, Oats, and various grasses.

GEOGRAPHICAL DISTRIBUTION.

The species is found all over Europe, and in this country occurs from Canada to North Carolina and perhaps farther south. It is found all through the western grain-growing States and is reported as doing some damage in California, although specimens from the west coast have not been authentically determined. They have a grain-louse there, however, working in the same way as in Eastern wheat-fields, and it is probably the same species.

LIFE HISTORY.

The life history of the species has by no means been made out with the accuracy with which we should like to be able to present it, although for a number of years past we have been seeking the missing links in its full life cycle. The points not yet definitely

determined are: (1) the exact number of generations (doubtless somewhat variable); (2) the intervals between the winged generations; (3) the winter habitat, and particularly the *locus* of the winter egg. We have found wingless parthenogenetic females on wheat late in April. Winged parthenogenetic females begin to appear late in May and there is a succession of agamic generations on wheat and on oats until harvest time. The rapid increase of the insect's natural enemies at this time, however, practically exterminates it about this time and renders it extremely difficult to continue observations whether in the field or the vivaria. We particularly urged and instructed our Indiana agent, Mr. Webster, who was well situated to carry on the needed studies, to follow the development during this period the past season, but he signally failed. Adults placed on various kinds of grasses in breeding cages invariably died. During our absence in Europe the past summer Mr. Howard had plots of spring wheat and timothy planted on the Department grounds, and these were several times stocked with lice received from Indiana, with the result that all soon died. He also made several attempts in August to import living individuals from Canada with the help of Mr. James Fletcher, but all specimens died on the journey.

In 1884, however, we sent Mr. Pergande on a trip in the neighborhood of Washington to study the species, and while he also failed in colonizing it in breeding cages he found larvæ and pupæ about the end of June on green Rye and Oats, Red-top (*Agrostis vulgaris*), Chess (*Bromus secalinus*) and Orchard Grass (*Dactylis glomerata*), the wheat at this time being nearly all harvested. In the same way Mr. Webster found large numbers of individuals late in June on Blue Grass (*Poa pratensis*), long distances from wheat-fields, but every one was parasitized. These observations prove, however unsuccessful breeding-cage experiments may have been, that the species bridges over the gap between wheat harvest and the appearance of fall wheat by migrating to the midsummer grasses.

When fall-sown wheat makes its appearance along in September, lice are again found upon it although in very small numbers. Full-grown wingless females have been found by Mr. Webster upon fall wheat as early as September 1, and from this date on until December 30 he has found them on wheat continuously. He has also observed the sexual individuals pairing November 11 and December 3, but has failed to get the winter-egg.

From the foregoing summary of what has been observed, and from analogy in the known life habits of allied species, we may conclude that the winter-egg is laid upon winter wheat, and that, although individuals may live until late in the winter, it is in this winter-egg state on wheat that the species normally hibernates and from which the stem-mother hatches in spring to give rise to the prolific wingless generations of late spring and early summer.

NATURAL ENEMIES.

Although the natural enemies of this species play an all-important part in its economy we can not here devote any space to their specific consideration beyond enumerating and illustrating the more important of them. It is largely due to these enemies that the lice are not abundant every year and it is entirely due to their good offices that the lice so suddenly disappear, as they did the present year, in late

June and early July. The climatic conditions were exceptionally favorable to the increase of the lice, and the natural enemies were not able to multiply with sufficient rapidity to overcome them until much later in the season than usual. The season's observations have more than doubled the number of these insect enemies which had previously been observed.

LIST OF INSECT ENEMIES OBSERVED IN 1889.

BEETLES.

Podabrus tomentosus Say (family *Lampyridæ*).
Coccinella 9-notata Herbst. (family *Coccinellidæ*).
Hippodamia parenthesis Say (family *Coccinellidæ*).
Hippodamia convergens Guérin (family *Coccinellidæ*).
Hippodamia 13-punctata Linnæus (family *Coccinellidæ*).
Hippodamia glacialis Fabricius (family *Coccinellidæ*).
Coccinella sanguinea Linnæus (family *Coccinellidæ*).
Anatis 15-punctata Olivier (family *Coccinellidæ*).
Megilla maculata DeGeer (family *Coccinellidæ*).

The Coccinellids or Lady-birds are given in about the order of their relative importance.

TWO-WINGED FLIES.

Allograpta obliqua Say (family *Syrphidæ*).
Syrphus americanus Wiedemann (family *Syrphidæ*).
Sphærophoria cylindrica Say (family *Syrphidæ*).

From this last species were reared two parasites which reduce its usefulness. They are *Bassus sycophanta* Walsh and *Hemiteles syrphicola* Riley MS.

TRUE INTERNAL PARASITES.

Aphidius avenaphis Fitch (family *Braconidæ*).
Aphidius granariaphis Cook (family *Braconidæ*), Plate I, Fig. 7.
Diæretus brunneiventris Ashmead (family *Braconidæ*), Plate VI, Fig. 1.
Isocratus vulgaris Walker (family *Chalcididæ*), Plate VI, Fig. 2.
Encyrtus websteri Howard (family *Chalcididæ*), Plate VI, Fig. 4.
Pachyneuron micans Howard (family *Chalcididæ*), Plate VI, Fig. 5.
Tetrastichus ingratus Howard (family *Chalcididæ*).
Megaspilus niger Howard (family *Proctotrupidæ*), Plate VI, Fig. 6.
Allotria tritici Fitch (family *Cynipidæ*), Plate VI, Fig. 3.

Of these internal parasites the second mentioned was the most abundant and important. We have shown at Plate I, Fig. 5, the appearance of the swollen louse after the parasite has escaped, and at Fig. 6 the appearance of the nearly developed parasite taken from the body of the Aphid.

Certain persons seeing English sparrows in the wheat fields have thought that the birds were feeding upon the lice, but Mr. C. M. Weed, who had a number shot while on wheat and examined their stomachs, states that the examination showed that it was the grain which they were after, and that they ate no lice except a few which were accidentally taken with the grain.

OTHER PLANT-LICE FOUND IN WHEAT FIELDS.

Observations are complicated by the fact that several other species of plant-lice are found in greater or less numbers upon wheat. The common Apple Plant-louse (*Aphis mali* L.) is often found on wheat after the appearance of the winged generation upon apple, and, indeed, it is a question whether this species, in view of what we know of its summer migrations, should really be known as the Apple Plant-louse any more than the Hop Plant-louse should be called the Plum

Plant-louse. Another species of the true genus *Aphis*, probably undescribed, is also often found on wheat, and an undescribed species of each of the Aphid genera *Toxares*, *Megoura*, *Callipterus*, and *Rhopalosiphum* are also found in the wheat fields, while according to the observations of the past summer the European *Siphonophora granaria* Kirby, following Buckton's figures and descriptions, also occurs in our wheat fields and should not be considered synonymous with *avenæ* Fabr.

PROPER NAME OF THE SPECIES.

It is tolerably certain that the species which we have been dealing with is the Fabrician *Siphonophora avenæ*, and that the species described by Kaltenbach as *S. cerealis* is a synonym, while the species described by Kaltenbach as *S. avenæ* is a different thing, the description corresponding exactly with our *Aphis mali*. As stated in the preceding paragraph, Kirby's *S. granaria* is a different thing, although this name was used by some writers in this country the past summer. Buckton, considering Kirby's *granaria* and Fabricius' *avenæ* identical, adopted the former name for the reason, as he says, that "Fabricius gave no description of his *Aphis avenæ*;" but a glance at the Entomologia Systematica, 1794 ed., shows a seven-line description, certainly enough to carry the name. Buckton probably referred only to one of Fabricius' earlier works.

CAUSES OF THE PAST SEASON'S OUTBREAK.

One of the commonest axioms connected with this insect is the association of its exceptional increase with very dry years, and in searching for the reasons why this insect multiplied so abundantly and remained so much longer in the field than usual during the past summer the natural inference is that the season must have been a dry one in the infested localities. To test the theory we have drawn up a table from data kindly furnished us by the Chief Signal Officer, General A. W. Greely, which indicates in the six States of Kentucky, Ohio, Indiana, Illinois, Wisconsin, and Michigan the average precipitation (average for all stations reporting) for the months from January to June in the years 1887, 1888 and 1889:

KENTUCKY.*

	Highest.			Lowest.			Average.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
January	4.73	6.19	5.80	1.23	2.35	2.32	3.22$\frac{1}{5}$	4.52	3.59$\frac{2}{3}$
February	10.11	3.79	2.58	4.60	1.70	0.88	7.53$\frac{1}{6}$	2.50	1.82$\frac{3}{4}$
March	6.80	5.82	4.30	1.88	2.95	0.21	3.61	4.95$\frac{1}{3}$	1.66$\frac{3}{25}$
April	9.00	4.48	3.76	1.50	2.45	0.51	5.22$\frac{2}{3}$	3.37$\frac{5}{9}$	1.80$\frac{2}{25}$
May	4.45	3.93	7.01	1.57	2.42	2.46	3.12$\frac{1}{5}$	3.12$\frac{2}{3}$	4.38$\frac{11}{24}$
June	3.00	6.00	8.04	1.33	1.95	1.88	1.86$\frac{1}{2}$	3.32$\frac{2}{3}$	5.05$\frac{15}{23}$

OHIO.

	Highest.			Lowest.			Average.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
January	3.50	6.15	5.78	0.25†	1.56	0.64	2.08$\frac{31}{51}$	3.54$\frac{7}{9}$	3.05$\frac{9}{16}$
February	10.75	4.03	3.58	3.05	0.75	0.42	6.98$\frac{41}{52}$	1.77$\frac{16}{53}$	1.47$\frac{63}{4}$
March	4.50	8.50	3.19	0.54	1.43	0.40	2.26$\frac{29}{51}$	3.66$\frac{41}{53}$	1.59$\frac{13}{34}$
April	8.28	7.00	3.16	1.13	0.66	0.38	3.86$\frac{36}{53}$	2.05$\frac{17}{55}$	1.91$\frac{7}{22}$
May	6.25	7.50	8.22	1.28	2.00	1.65	3.00$\frac{6}{13}$	3.79$\frac{34}{57}$	3.78$\frac{46}{67}$
June	6.67	6.89	7.80	1.69	1.59	1.37	4.02$\frac{4}{49}$	3.40$\frac{55}{56}$	4.21[illegible]

* Defective for 1887 on account of small number of station returns.
† For twenty-four days.

MICHIGAN.

	Highest.			Lowest.			Average.		
	1887.	1888.	1889.	1887.	1888.	1889.	1887.	1888.	1889.
January	5.10	5.07	4.00	0.86	0.48	1.00	3.18$\frac{1}{13}$	2.00$\frac{57}{65}$	2.12$\frac{11}{89}$
February	7.16	3.83	4.38	1.20	0.50	0.57	4.50$\frac{19}{26}$	1.83$\frac{61}{66}$	1.70$\frac{11}{90}$
March	2.35	4.66	2.27	0.22	1.25	0.04	1.25$\frac{23}{30}$	2.72$\frac{56}{81}$	0.99$\frac{29}{93}$
April	3.44	5.49	4.26	0.41	0.91	0.10	1.38$\frac{29}{35}$	1.95	1.45$\frac{90}{91}$
May	4.30	6.15	7.32	0.70	1.69	1.16	2.21$\frac{9}{22}$	3.56$\frac{9}{62}$	4.21$\frac{1}{49}$
June	5.64	4.98	7.36	0.43	0.45	1.47	2.49$\frac{1}{9}$	2.54$\frac{57}{61}$	4.32$\frac{34}{87}$

INDIANA.

January	4.55	5.83	4.96	0.50	1.18	1.05	2.14$\frac{1}{2}$	3.03$\frac{7}{12}$	2.84$\frac{5}{11}$
February	15.90	6.36	3.62	2.97	0.75	0.74	6.33$\frac{2}{17}$	2.25$\frac{13}{34}$	1.59$\frac{21}{34}$
March	5.58	11.05	2.46	0.65	1.78	0.80	2.45$\frac{23}{33}$	4.70$\frac{7}{12}$	1.45$\frac{27}{35}$
April	10.78	4.13	2.24	1.12	1.00	0.55	4.06$\frac{6}{11}$	2.25$\frac{19}{35}$	1.10$\frac{9}{34}$
May	6.10	7.79	9.25	1.25	1.50	2.90	3.41$\frac{5}{31}$	3.87$\frac{22}{35}$	5.50$\frac{13}{34}$
June	5.98	8.64	7.32	0.10	1.37	2.60	2.54$\frac{5}{7}$	3.70$\frac{24}{33}$	4.68$\frac{14}{33}$

ILLINOIS.

January	4.56	7.59	4.61	0.43	....	1.01	1.91$\frac{2}{73}$	2.25$\frac{2}{15}$	2.23$\frac{11}{14}$
February	9.83	3.90	4.87	0.22	0.08	0.59	4.66$\frac{3}{23}$	1.84$\frac{9}{73}$	1.76$\frac{28}{33}$
March	6.56	6.59	4.34	0.35	0.09	0.70	2.23$\frac{6}{73}$	3.51$\frac{31}{72}$	1.62$\frac{18}{59}$
April	6.30	3.50	4.30	0.38	0.08	0.12	2.37$\frac{47}{69}$	1.78$\frac{21}{72}$	2.02$\frac{19}{28}$
May	6.50	8.86	10.63	0.80	0.24	1.91	2.72$\frac{66}{67}$	5.01$\frac{1}{35}$	4.81$\frac{20}{29}$
June	3.78	9.77	11.49	0.07	0.12	1.50	0.64$\frac{49}{69}$	4.34$\frac{52}{65}$	5.10$\frac{11}{54}$

WISCONSIN.

January	2.69	3.55	3.75	0.25	1.16	1.41	2.03$\frac{1}{5}$	1.86$\frac{2}{3}$	2.27$\frac{9}{13}$
February	5.16	3.60	3.45	1.36	0.61	0.88	3.79$\frac{1}{2}$	1.65$\frac{1}{11}$	1.93$\frac{15}{16}$
March	2.14	5.69	1.48	0.26	1.70	0.20	1.17	3.21$\frac{4}{11}$	0.75$\frac{17}{19}$
April	2.70	3.38	10.38	0.96	1.81	0.50	1.58$\frac{1}{6}$	2.67$\frac{10}{11}$	1.50$\frac{18}{21}$
May	2.50	6.30	8.05	0.50	2.21	2.30	1.46$\frac{1}{2}$	4.48$\frac{5}{11}$	4.12$\frac{5}{7}$
June	4.50	7.00	9.82	0.41	1.11	1.50	1.76	3.33$\frac{3}{11}$	3.77$\frac{9}{11}$

Examining this table for points in common in the six States, and which are at the same time peculiar to the season of 1889, we notice that the months of February, March, and April were very dry, and that in May and June there was a sudden and very marked increase in precipitation holding over the entire region. May and June, however, were the very months in which the insects were most abundant and were oftenest reported, and in this very fact is a seeming refutation of the accepted theory. We have had occasion to disprove a similar prevalent belief in the connection between great Army Worm years and drought, and to show that wet, cloudy weather rather favors the development of the worms (Third Report U. S. Entomological Commission, pp. 114, 115). So far as plant-lice are concerned, they almost all thrive best during cloudy or wet weather and moderate temperature, as represented by the ordinary spring, rather than during dry, and especially during hot weather. Heavy storms or thunder showers, or continued drenching rains, on the contrary, are detrimental to them, and by the exceptionally heavy and continued rains which characterized the summer in the Atlantic States may be explained the relative scarcity of the Grain Aphis there this year, as compared with the States farther west, where the precipitation was less. A few calm, temperately warm, and fair days at the proper

season to favor migration and spread will have more to do in determining injurious increase than the character of the weather for weeks or months afterward, while the nature of the preceding winter may also be all-important. This we have clearly shown in reference to the Hop Plant-louse, and also of other species which we have studied.

The explanation of the prevalence of the Grain Aphis the past summer is to be found, then, in the early spring months so favorable to Aphid increase, and in the subsequent absence of the usual hot spells, the summer temperature having been exceptionally low and equable, rather than in exceptional increase or decrease of rain. If anything, a rainy summer will promote increase for much the same reason which we have given at length in discussing its influence on the increase of the Cotton Worm (Fourth Report U. S. Entomological Commission, pp. 83–85). The rain unquestionably prevents the work of many of the enemies of the plant-lice which we have enumerated, and particularly the delicate little parasites of the braconid subfamily *Aphidiinæ*. These are minute four-winged creatures, which fly with a swift, darting motion from plant to plant, laying an egg first in one louse and then in another, their development being exceedingly rapid. Now rains deprive these parasites of their means of locomotion to a greater or less extent. Observations have proved that while the wings of allied parasitic hymenoptera dry slowly, the insects themselves may be partially immersed in water for hours without dying. Hence a rainy season tends to check the work of these parasites, but the rain once over they are ready, after their wings dry, to carry on their, to us, beneficent work. During wet weather, therefore, the plant-lice, unhampered by their foes, will increase with all the greater rapidity, providing other conditions of increase are favorable.

In this connection, and as emphasizing the foregoing generalizations, it may be stated as another important fact, that the plant-lice are more active in a lower temperature than are their numerous parasites, which flourish and multiply most rapidly in the heat of summer.

REMEDIES.

Working, as this insect does, all through a close-growing field of wheat, acres in extent, the application of insecticide mixtures is out of the question, and to experiment with them as some entomologists have done the past summer is a mere waste of time. We know that a dilute kerosene emulsion will kill them, but it can not be practically applied. Then, too, the insect lives as readily upon Oats, Barley or Rye, and also upon a number of wild and cultivated grasses, and if it were destroyed upon or with any one food-plant its numbers upon others would not be affected. It has (at least so far as we now know) no permanent and alternate winter resting plant upon which we can attack it as we can attack the Hop Louse upon Plum, and altogether the problem of remedies is one which can not be solved, for the present at least. No one has ever suggested a practical remedy, and we find ourselves unable to do so now. We agree with Professor Forbes when he says:

> * * * There is probably nothing to be done with it that is of any practical value. So sensitive a creature can best be left to the Weather Bureau and its natural enemies. (*Orange Judd Farmer*, June 29, 1889, and other Western papers of about the same date.)

It is only once in a great while that any damage is done, and even the enormous numbers of the past season have, according to statistical reports, not seriously affected the wheat and oats crops as a whole.

We have already shown that the probable place of deposit of the majority of the winter-eggs is upon winter wheat, and consequently much less damage is to be expected in the purely spring wheat belt. Where only winter wheat is grown the damage, although greater than in the exclusively spring wheat region, will probably be less than in localities where both spring and winter wheat are raised, on account of the migration of the first generation of winged lice from winter wheat to less advanced spring wheat. In the same way oats grown next to winter wheat will be more apt to suffer. This is always presupposing a favorable season for the development of the lice. In the vast majority of seasons, as experience has shown, although the lice may appear in spring in great numbers, their insect enemies are apt to check them so effectually as to prevent appreciable damage.

THE WORK OF FIELD AGENTS.

A BRIEF STATEMENT OF THE WORK OF THE FIELD AGENTS OF THE DIVISION.

Mr. D. W. Coquillett, the agent at Los Angeles, Cal., was engaged during the first half of the year in superintending the breeding and distribution of the imported Vedalia, and the success which has attended this work has already been pointed out.

Experiments with a view of finding a cheaper method of using the hydrocyanic acid gas against scale insects were instituted and were very successful. The expense attending the use of this gas by the new method is scarcely one-third as much as by the method formerly employed. Much of the cumbersome machinery used in the earlier work is also found to be unnecessary; and this, with the considerable reduction in the expense of the process, removes many of the objections to this means of combating scale pests, and will doubtless bring it into more general use.

We have for some time felt, as intimated in our last report, that the hopes engendered by the promise of the gas treatment and the special attention which, through Mr. Coquillett, we had devoted thereto, while fully justified, had caused some neglect of the washes which previous experiments had proved advantageous and satisfactory. We have urged the sufficiency of these, and Assistant Secretary Willits, who has been among the orange groves of California and fully comprehends the situation, has strongly seconded our efforts in his correspondence already alluded to. We desired, therefore, that Mr. Coquillett should undertake some supplementary and decisive tests with the resin soaps and compounds on trees thickly infested with the Red Scale (*Aspidiotus aurantii*). He has carried out many additional experiments with these substances with the result of rendering the washes more effective, and of obtaining valuable facts regarding the method of application, and the season when the treatment will be followed with the best results.

The best solution for use during the hotter part of the year is prepared as follows: Resin, 18 pounds; caustic soda (70 per cent. strong), 5 pounds; fish-oil, 2½ pints; water to make 100 gallons.

The necessary ingredients are placed in the boiler and a sufficient quantity of cold water added to cover them; they are then boiled until dissolved, being occasionally stirred in the meantime, and after the materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over; too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve or through a piece of Swiss muslin, and this is usually accomplished when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound would be greatly accelerated if the resin and caustic soda were first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake weighing about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required.

These experiments, together with those recorded in our previous reports, establish the value of the resin washes against scale insects, and show conclusively that the complete control of the latter may be effected by a thorough use of these substances.

The Eureka Insecticide of E. Bean, Jacksonville, Fla., was also tested and failed to furnish results of value against the scale insects.

Mr. Albert Koebele, the agent of the Division at Alameda, Cal., returned from his successful trip to Australia in April, and after repairing to Washington for personal consultation before we left for Paris, proceeded to his post at Alameda, Cal. Some time was taken up in writing out his report upon work done in Australia, which has been published as Bulletin 21, and also in assisting in raising and distributing the Australian ladybird in the northern part of the State.

His work has otherwise consisted in breeding and studying various injurious insects that have attracted attention and in collecting and preparing a lot of valuable museum material. Among the insects studied and worthy of particular mention were the wood-boring beetle known as *Polycaon confertus,* which damages fruit trees, and the western representative of our Twelve-spotted Squash-beetle, *Diabrotica soror,* of which he was fortunate enough to find an important parasite. This parasite seems to have been discovered in 1886 by Mr. Alex. Craw, of Los Angeles, and the present season both Mr. Coquillett and Mr. Koebele have succeeded in breeding it. Mr.

Coquillet has published a scientific description of the species in INSECT LIFE, vol. II, p. 233, naming it, in honor of its discoverer, *Celatoria crawii*. The Western Tent Caterpillar, *Clisiocampa californica*, has also been studied and a number of parasites reared. Considerable attention has also been paid to the cut-worms of the western coast. A careful study has been made of the Codling Moth and we are pleased to be able to announce that several new parasites have been bred from it, among them a parasite of the egg. These extremely beneficial insects we hope soon to report upon in full. Most of them are not found in the Eastern States and there may be a chance of bringing some of them East. Interesting studies have also been made upon the Hessian Fly, which is becoming more abundant in California, and also upon certain grasshoppers.

The work of the Missouri agent, Miss Mary E. Murtfeldt, may be summarized as follows:

Experiments which we arranged to have made with ammoniacal solutions of white arsenic on a large number of injurious insects proved unfavorable to its use on account of the injury to the foliage. Experiments with arsenic in simple aqueous solution proved the efficacy of this substance in most cases, and it was found to be less injurious to the foliage than when used with ammoniacal solvents.

Experiments with Pyrethrum in powder and in liquid suspension gave results which corroborated its value within the limits we have set forth in previous writings.

She tested also a new exterminator known as "X O Dust" and found it effective against plant-lice, cabbage bugs, and a few other soft-bodied species. Its action seemed to be much like that of Pyrethrum powder, which it scarcely equals in strength.

Other poisons and substances were also tested but have not yet been reported upon.

A small leaf-beetle, the larva of which was extremely destructive to Spinach, was carefully studied, as it is new to the list of injurious species. This insect is *Disonycha collaris* and has been reported upon in full.

A rose slug (*Cladius isomera*), not heretofore observed in that section of the country and which produced several successive broods, was also studied and experimented upon.

A small bug (*Cosmopepla carnifex*) was also noted as a new foe in the flower garden, appearing upon roses, chrysanthemums, and other valuable plants in great numbers. Other insect enemies were studied as to obscure points in their life history. The season was characterized by an almost phenomenal scourge of plant-lice. Scarcely any kind of vegetation escaped their blighting influence in the early part of the season and considerable loss in grain and other crops resulted.

The Iowa agent, Prof. Herbert Osborn, has, in addition to continuing his work upon insects affecting domestic animals, devoted most of his time to the study of insects affecting meadows and pastures as connected indirectly with his main work. The ground covered by this latter subject is so great that the present season has been devoted mainly to the leaf-hoppers and other Homopterous insects affecting pastures.

He feels sure, after his season's study, that, taking year after year, the injury caused to pastures by insects of various kinds is fully equal to the amount consumed by the stock ordinarily pastured on such land. It is evident, then, that the prevention or destruction of

the insect injuries would add an equivalent amount to the return from such lands.

A careful estimate of the number of leaf-hoppers alone gives nearly a million to the acre. This estimate was made by throwing a net down vertically and counting the area inclosed by the ring. This was repeated a number of times and an average was struck, and then this average was multiplied by the computed number of times which the area of the net would go into one acre. Professor Osborn thinks that this estimate is really far below the actual number frequently occurring during seasons when they are ordinarily abundant and greatly under the number when they have multiplied to an unusual degree. In reply to the possible objection that they are too small to consume a great amount of food and that a million leaf-hoppers would not exceed in bulk the half of a single cow it should be remembered that leaf-hoppers grow very rapidly and usually consume proportionately a great amount of food, and that they extract the most nutritious part of the grass.

The different species of leaf-hoppers accomplishing this damage have been studied in detail, and careful experiments with remedies have been made during the season. Professor Osborn is of the opinion that remedies can readily be adopted against them costing no more than from 2 to 10 cents per acre, and by means of which not only the leaf-hoppers but the destructive grasshoppers can be destroyed. He finds in the first place that many of the leaf-hoppers hibernate in grass and are tolerably active during late fall and early spring, but at these times, while the weather is cool, do not ordinarily fly to any great distance, but progress by leaping. Burning over the pastures then at this season will destroy great numbers of the pests. Cutworms and Turf Web-worms will on the contrary not be practically affected by this remedy as they hibernate beneath the surface of the ground. A piece of ground burnt over in early spring, although surrounded by unburnt grain land on three sides, kept its color until late summer.

If deep cheese-cloth nets are made and attached to light frames 8 or 10 feet long and run rapidly over the pasture by a boy, at each sweep vast numbers can be captured at little expense.

The best remedy, however, is the use of either one of the "hopper dozers" frequently mentioned in our articles upon destructive grasshoppers, or a strip of building paper attached to a light wooden frame and coated with coal tar or gas tar and run through the fields either mounted on runners or carried by hand close to the ground. Either of these arrangements should be worked during the warm days in the fall or spring in order to catch the hibernating species before they deposit their eggs. Repeat the operation if it seems necessary in July.

The vast majority of stock-raisers will not consider it necessary to try the use of the nets or shields, but the spring or fall burning of the pasture lands is the simplest remedy and an excellent thing to do.

Professor Osborn has paid attention to other insect pests which became prominent during the season and has made the important discovery that the Dog-wood Plant-louse (*Schizoneura corni*) is identical with a plant-louse which infests the roots of grass during summer. In other words, this insect in summer lives on the roots of grass and in the fall migrates to dog-wood. The life history of this insect has been carefully worked out, and the observation, while very interesting from an entomological stand-point, may also prove to be of considerable value economically.

The Indiana agent, Prof. F. M. Webster, returned from Australia early in April, where he had been sent, as mentioned in the article on the Fluted Scale, to report upon the agricultural aspects of the Melbourne Exposition, and took up his observations at La Fayette upon insects affecting grains and grasses. He has studied the past season, particularly, the Wheat Stem-maggot (*Meromyza americana*), the Western Striped Cut-worm (*Agrotis herilis*), the Army Worm (*Leucania unipuncta*), the White Grub (*Lachnosterna* spp.), the Wheat Wire-worm (*Agriotes mancus*), the Swamp Sphenophorus (*Sphenophorus ochreus*), the Chinch Bug (*Blissus leucopterus*), and the Grain Plant-louse (*Siphonophora avenæ*). He reports upon all of these insects as well as upon some others of less importance. The principal points of interest which he brings out are the finding of another food-plant for the Wheat Stem-maggot in blue grass. He has also experimented upon the relative susceptibility of certain varieties of wheat, in which he shows that Michigan Amber is attacked with only about one-fourth of the severity of Velvet Chaff. From the Western Striped Cut-worm he has reared a new natural enemy, viz, *Anthrax hypomelas*. This is interesting as confirming some few previous notes of the parasitism of Anthrax upon Lepidopterous larvæ. Several outbreaks of the Army Worm, in which the damage has fallen upon the rye crop, are mentioned.

The life history of the Swamp Sphenophorus has been made out as detailed in Vol. II, No. 5, INSECT LIFE, November, 1889. This insect was found breeding in the roots and stems of a species of Rush (*Scirpus atrovirens*) rendering the system of prevention very easy. These plants must be destroyed root and stem the season prior to devoting the ground to corn. The most practical and probably the most effective way of destroying it is to sow rye upon the land the first season after breaking.

In regard to the Chinch Bug, he has endeavored to show by carefully tabulating the districts in the State of Indiana in which the bugs abound in years of prevalence, the districts in which the greatest amount of wheat is grown and the comparative rain-fall in the different districts, whether the immunity of certain portions of the State can be traced to climatic differences or to the nature of the principal crops.

He has experimented with fungus diseases of the Chinch Bug, distributing specimens received from Prof. F. H. Snow, of Lawrence, Kans., but the experiments were not satisfactory. He succeeded in getting the fungus established at two points in Indiana, but his experiments show that it will not prove contagious unless great masses occur and the weather be over-moist.

The facts which he collected in regard to the Grain Aphis have been referred to in the article upon this subject which appears in the early portion of this report.

The work of the agent stationed in Nebraska, Mr. Lawrence Bruner, has been somewhat diversified. He has continued work on the family Acridiidæ, which includes all of the destructive locusts or grasshoppers, and in this line reports the present year upon an investigation of a reported locust outbreak at Nephi City, Utah. The species concerned were mainly local and non-migratory, although a few specimens of the Rocky Mountain Locust (*Melanoplus spretus*) and the Destructive Cricket (*Camnula pellucida*) were found. There seems to be no reason, however, for alarm another season. The outbreak of the Rocky Mountain Locust in Minnesota, referred to in the

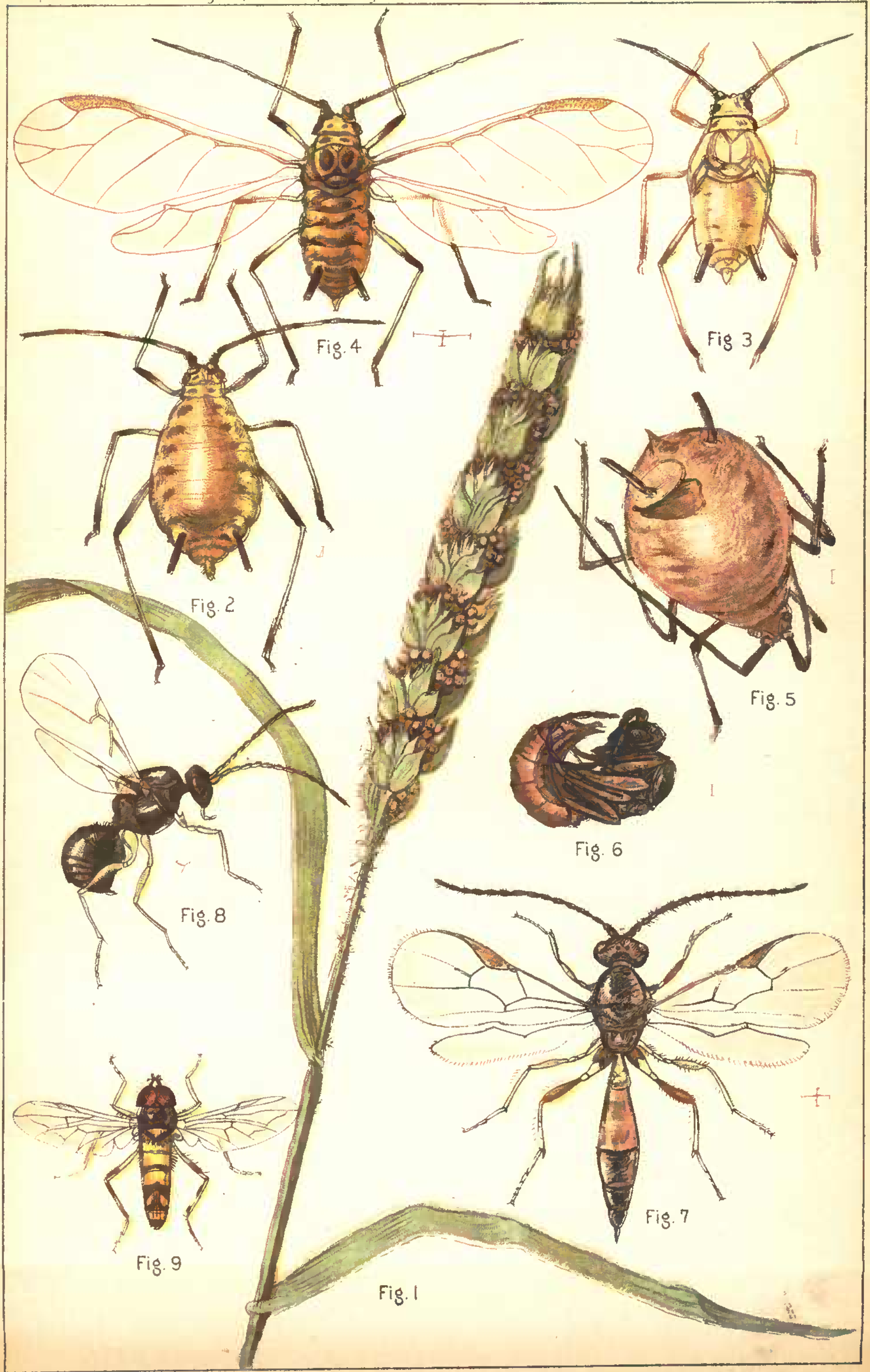
introduction to our last report, has been completely stamped out by the energetic work of Mr. Otto Lugger, the entomologist of the station, with the intelligent co-operation of the State authorities. There was, therefore, no necessity for Mr. Bruner's services in this part of the country.

Mr. Bruner reports an interesting case of the fungus disease of a local species of locust in the vicinity of Lincoln, Nebr. The large Differential Locust (*Melanoplus differentialis*) was destroyed by this. The fungus causing the disease is known as *Entomphthora calopteni* Bessey. Some study was made of this disease and large numbers of the dead locusts were collected.

An important study which we have had Mr. Bruner take up the past season is that of the insects detrimental to the growth of young trees on tree claims in Nebraska and other portions of the West. Little more was done the present season than to collect and tabulate the species thus engaged. About thirty species of importance were observed, distributed as follows: Two saw-flies, six beetles, fifteen caterpillars, two tree crickets, and three locusts. The causes of injury have been studied and comparative freedom of different plants tabulated. He finds that of the trees and insects observed the Catalpa and Russian Mulberry are not damaged, the Ash is affected by three, the Box Elder by two or three, the Willow by a dozen or more, the Cottonwood by four or five, the Soft Maple by several, the Elm by two and the Honey Locust by two. Only such insects have been studied as attack the young trees during their first year's growth. Other species commence their injuries on the trees later on.

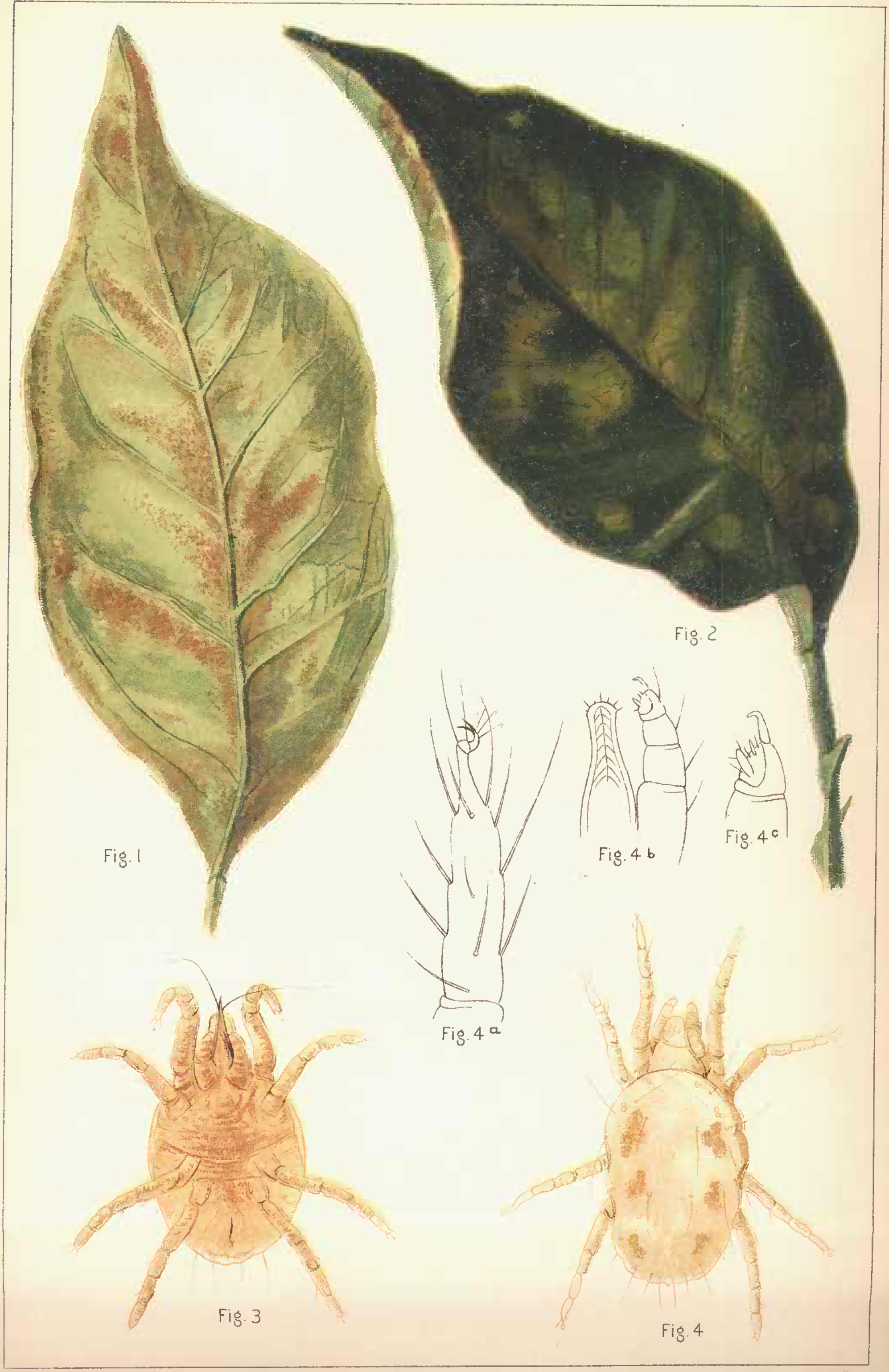
The Army Worm was recorded for the first time in the State of Nebraska in injurious numbers. The Blue Grass Weevil he has fortunately succeeded in finding in all stages. The species is known as *Sphenophorus parvulus*, and Mr. Bruner has found that it lays its eggs at the roots of blue grass (*Poa pratensis*) and that two generations appear during the year, one in the spring and the other in the early fall. There is a possibility, however, that it is only single brooded and that the individuals appearing in the fall are only advance specimens and winter over as beetles. The Corn Rootworm (*Diabrotica longicornis*) is reported as becoming alarmingly common in eastern Nebraska, while the Corn Ear-worm (*Heliothis armigera*) has done considerable damage to the ears of field corn.

NOTE.—For explanation to plates see p. 361.



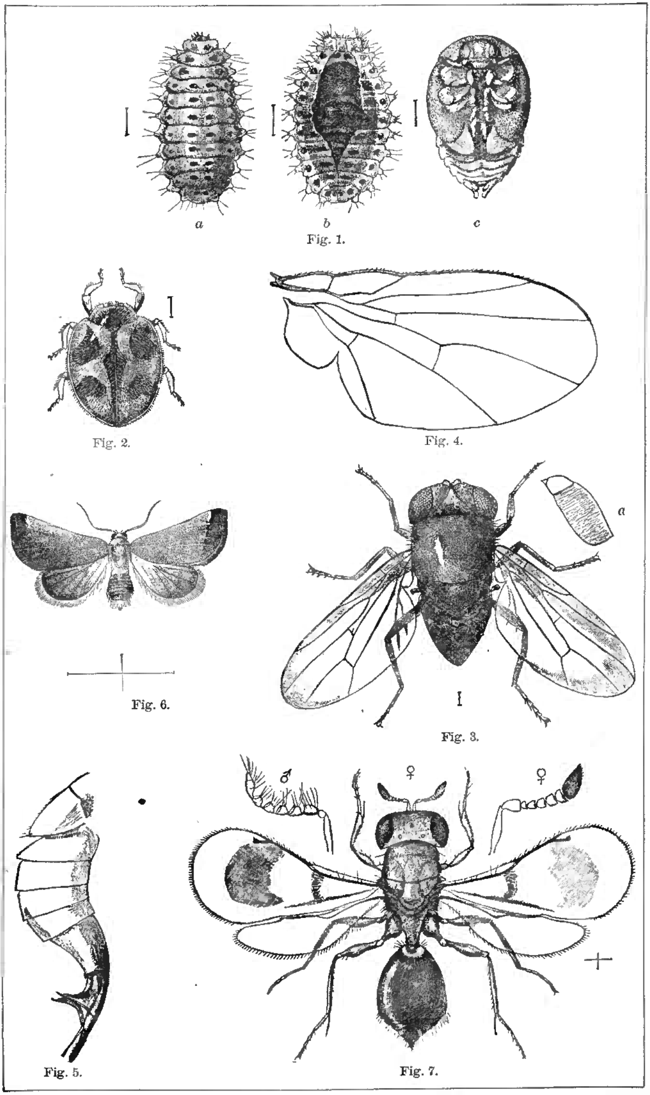
THE GRAIN PLANT-LOUSE AND ITS ENEMIES.

Sackett & Wilhelms Litho Co. New York.



THE SIX SPOTTED MITE OF THE ORANGE.

Sackett & Wilhelms Litho Co. New York



ENEMIES OF THE FLUTED SCALE.

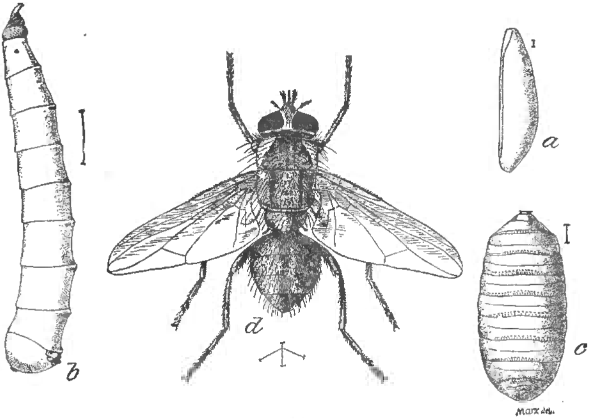


Fig. 1.

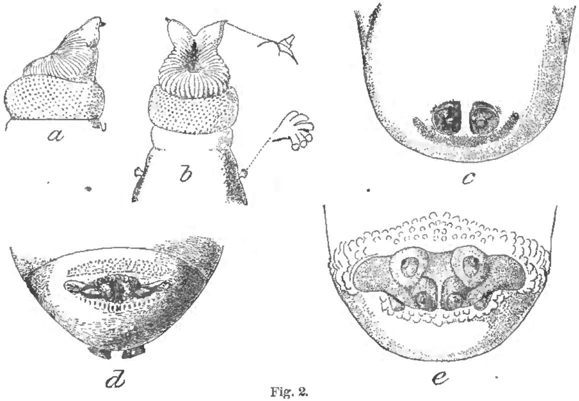


Fig. 2.

THE HORN FLY.

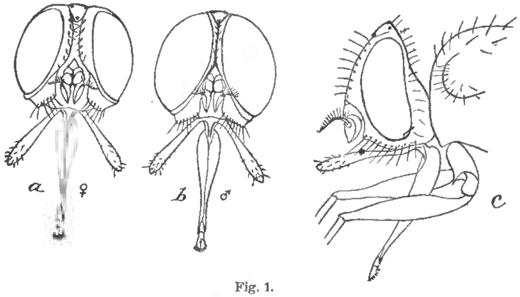


Fig. 1.

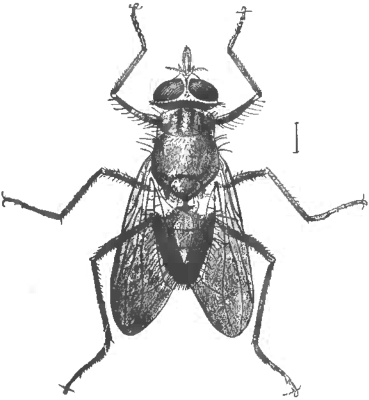


Fig. 2.

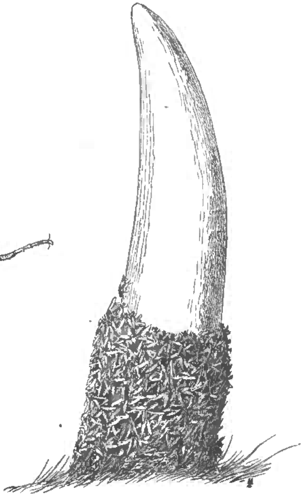


Fig. 3.

THE HORN FLY.

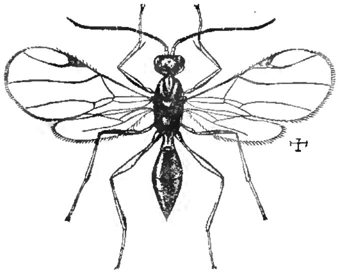


Fig. 1.

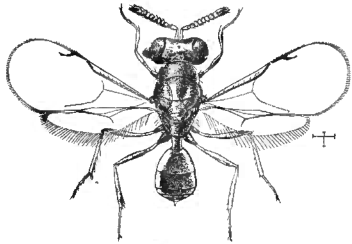


Fig. 2.

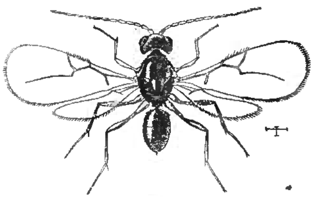


Fig. 3.

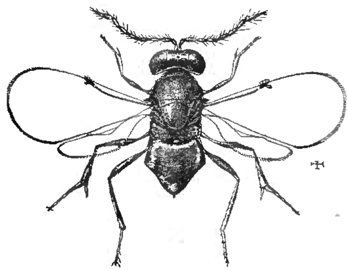


Fig. 4.

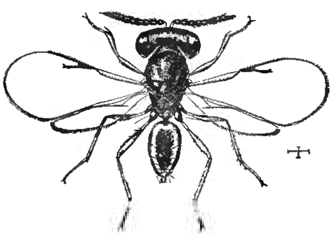


Fig. 5.

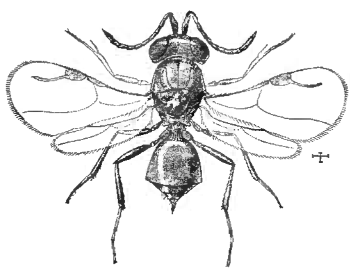


Fig. 6.

PARASITES OF THE GRAIN PLANT-LOUSE.

EXPLANATION TO PLATES TO REPORT OF ENTOMOLOGIST.

Where figures are enlarged the natural sizes are indicated in hair-lines at side, unless already indicated in some other way on the plate.

EXPLANATION TO PLATE I.

THE GRAIN PLANT-LOUSE AND ITS ENEMIES.

(Original.)

FIG. 1. Head of wheat, showing lice in position in late May and June.
FIG. 2. *Siphonophora avenæ.* Wingless parthenogenetic female—enlarged.
FIG. 3. The same, pupa of winged migrant—enlarged.
FIG. 4. The same, winged migrant—enlarged.
FIG. 5. The same, wingless female, with swollen body, showing exit hole of parasite—enlarged.
FIG. 6. *Aphidius granariaphis*, nearly developed adult, taken from body of louse—enlarged.
FIG. 7. The same—enlarged.
FIG. 8. *Allotria tritici*—enlarged.
FIG. 9. *Allograpta americana*—natural size.

EXPLANATION TO PLATE II.

THE SIX-SPOTTED MITE OF THE ORANGE.

(Original.)

FIG. 1. Under surface of orange leaf, showing the work of the mite—natural size.
FIG. 2. Upper surface of orange leaf, showing effect of the work of the mite—natural size.
FIG. 3. *Tetranychus 6-maculatus*, adult from below—enlarged.
FIG. 4. The same from above—enlarged; *a*, claw; *b*, proboscis and palpus; *c*, palpus—still more enlarged.

EXPLANATION TO PLATE III.

ENEMIES OF THE FLUTED SCALE.

FIG. 1. *Vedalia cardinalis: a*, full-grown larva; *b*, pupa, within larval skin; *c*, pupa—enlarged. (After Riley.)
FIG. 2. The same, adult—enlarged. (After Riley.)
FIG. 3. *Cryptochætum iceryæ*—enlarged; *a*, antennæ—still more enlarged. (After Riley.)
FIG. 4. Wing of same—enlarged. (After Williston.)
FIG. 5. The same, abdomen of male showing genitalia—enlarged. (After Williston.)
FIG. 6. *Thalpochares cocciphaga*—enlarged. (Original.)
FIG. 7. *Ophélosia crawfordi*—enlarged. (Original.)

EXPLANATION TO PLATE IV.

THE HORN FLY.

(After Riley & Howard.)

FIG. 1. *Hæmatobia serrata: a*, egg; *b*, larva; *c*, puparium; *d*, adult in biting position—enlarged.
FIG. 2. The same: *a*, head of larva from side; *b*, ditto from below; *c*, anal stigmata of larva; *d*, anal segment of puparium from below; *e*, anal segment of larva from below—enlarged.

EXPLANATION TO PLATE V.

THE HORN FLY.

(After Riley & Howard.)

FIG. 1. *Hæmatobia serrata; a*, head of female from the front; *b*, ditto male; *c*, head of female from the side—enlarged.
FIG. 2. The same: adult in resting position—enlarged.
FIG. 3. The same: adults in resting position at base of horn—reduced.

EXPLANATION TO PLATE VI.

PARASITES OF THE GRAIN PLANT-LOUSE.

(Original.)

FIG. 1. *Diæretus brunnciventris*—enlarged.
FIG. 2. *Isocratus vulgaris*—enlarged.
FIG. 3. *Allotria tritici*—enlarged.
FIG. 4. *Encyrtus websteri*—enlarged.
FIG. 5. *Pachyneuron micans*—enlarged.
FIG. 6. *Megaspilus niger*—enlarged.

REPORT OF ORNITHOLOGIST AND MAMMALOGIST.

SIR: I have the honor to submit herewith my fourth annual report of the doings of the Division of Economic Ornithology and Mammalogy, covering the year 1889. It consists of two principal parts or sections in accordance with the two lines of work carried on by the division—the one, a study of the *Economic Relations* of mammals and birds which are beneficial or harmful from a directly economic stand-point; the other, a study of the *Geographic Distribution of Species*.

Early in the year it was decided to publish the results of the investigations of the division in two distinct series of papers, namely (1) farmers' bulletins; (2) faunal bulletins. Of the former the first number has appeared, entitled, "The English Sparrow in America;" of the latter two numbers have been published, entitled "North American Fauna." Several additional bulletins are now in an advanced stage of preparation and will appear at an early date.

The office force of the Division is wholly insufficient for the rapidly increasing demands of the investigations in hand, and the mere routine work has already outgrown the means at command for its proper accomplishment. The most constant and burdensome element of this work is the correspondence. During the year 1889 about four thousand letters were written, copied, indexed, and mailed, and several thousand circulars and schedules were distributed. Lists were prepared also, or franks written, for upwards of twelve thousand copies of the publications of the division, which have been distributed. During the same time the number of letters received was more than three thousand, and more than half of these were accompanied by schedules, lists, reports, or other records of observations, all of which were examined, indorsed, jacketed, and either filed for future reference or at once utilized in studies already in progress. Other routine work has consisted in comparing and correcting proof, preparing and revising card lists of correspondents, filing certain classes of reports received, type-writing franks for the distribution of documents to American and foreign correspondents, compiling a reference list of publications useful in the regular work of the division, preparing colored diagrams or maps in connection with the work on geographic distribution, and miscellaneous work.

Respectfully,

C. HART MERRIAM,
Chief of Division of Ornithology and Mammalogy.

HON. J. M. RUSK,
Secretary of Agriculture.

SECTION OF GEOGRAPHIC DISTRIBUTION.

CHARACTER AND OBJECT OF THE INQUIRY.

The primary object of mapping the geographic distribution of species is not only to show the limits of the regions inhabited by each, but also to ascertain the number, positions, and boundaries of the natural faunal and floral areas of the United States—areas which are fitted by nature for the life of certain associations of animals and plants, and which consequently are adapted for the growth of certain agricultural products and for the support of certain kinds or breeds of stock. The results of this study of the natural *life areas* of the country and of the fundamental facts, principles, and laws upon which they depend, are of the utmost value to practical and experimental agriculture, and are so intimately related to the work of the experiment stations that the investigations of the latter can not be fully utilized without them.

In order to understand this clearly it is necessary to bear in mind certain familiar facts which underlie the study of distribution. Everybody knows that polar bears, white foxes, and snowy owls inhabit the Arctic regions; that palm trees, monkeys, and crocodiles are found in the tropics; that cactuses, yuccas, and prairie dogs are characteristic of the arid lands of the West; and that the "big trees," redwoods, and plumed quails of California do not occur east of the Sierras. These are facts of common observation. And so we might go on, dividing and subdividing the lands of North America into major and minor provinces and areas, each of which may be characterized by the possession of many forms of life—associations of species—not found elsewhere.

The reason certain kinds of animals and plants inhabit certain definite parts of the earth's surface and do not occur in other parts where there are no impassable barriers to prevent, is that such species have become adapted, in the course of time, to particular combinations of physical and climatic conditions which prevail over those areas, and their sensitive organizations are not sufficiently plastic to enable them to live under other combinations of conditions.

The recent investigations of the division have demonstrated that mammals and birds and reptiles and insects and plants agree so well in distribution that a map showing the boundaries of an area inhabited by an association of species in one group will serve equally well for other and widely different groups. The reason of this coincidence in distribution in different branches of the animal and vegetable kingdoms over the same area is that all are exposed to the same surroundings and all are governed by the same general laws.

The point of greatest significance, so far as the practical agriculturist is concerned, is that what is true of animals and plants in a state of nature is true also of animals and plants as modified by the voluntary acts of man. Every race or breed of sheep, cattle, or swine, and every variety of grain or vegetable, thrives best under certain definite conditions of temperature, moisture, exposure, and so on. It follows that a map of the NATURAL LIFE AREAS of a country may be used by the farmer for the purpose of ascertaining the boundaries of the areas which are fitted by nature for the growth of certain crops and the support of certain kinds or breeds of stock; in other words, such a map, used in connection with information furnished by the experi-

ment stations, will tell the farmer what he can expect to produce most successfully and profitably on his own farm. Moreover—and this perhaps is of even greater importance—it will tell him what crops will *not* thrive in his neighborhood, thus saving the time and cost of experimental farming, which in the aggregate amounts to hundreds of thousands of dollars every year.

This is but one of the ways in which a knowledge of the distribution of species may benefit the practical agriculturist. It may help him also in his relations with injurious and beneficial species, as he would know beforehand just what species were to be looked for in his immediate vicinity.

RESTRICTIONS IMPOSED BY CONGRESS.

The division is hampered in the study of geographic distribution by the restrictions imposed in the phraseology of the act of Congress appropriating money for the investigations, no provision being made for any work except on mammals and birds. In effect, therefore, the division is prohibited by law from carrying on the most important work it has undertaken, namely, a comprehensive study of geographic distribution, and is prevented from mapping the natural life areas of the country except in so far as this may be done from a study based solely on mammals and birds.

URGENT RECOMMENDATION.

In view of the above facts and of the recent generous expenditures of public moneys for the advancement of related branches of Agricultural science, it would seem the part of wisdom to undertake at once a systematic *Biological Survey* for the purposes above indicated. It is urgently recommended that such a survey be established under the Department of Agriculture, and that the present Division of Ornithology and Mammalogy be merged into it.

WORK OF THE YEAR.

The work accomplished in the section of Geographic Distribution may be conveniently summarized under two heads, namely, (1) office work and (2) field work.

(1) *Office work.*—The office work has consisted in collecting and tabulating published and original records of occurrence, in indicating the same on base maps by means of color spots, and in working up the results of field work conducted by the division.

(2) *Field work.*—The object of the field work of the division is twofold: (1) the collection of material illustrating the geographic distribution of species; (2) the collection of material illustrating the economic relations of species.

During the past year the division has been able to keep but one man in the field continuously, but has employed three others for short periods. Mr. Vernon Bailey has carried out an unbroken line of field work, beginning in Utah and extending through parts of Nevada, Arizona, southern California, and New Mexico. Mr. T. S. Palmer made a six months' trip on the Pacific coast in northern California, Oregon, and Washington. Mr. Charles A. Keeler spent about a month in Nevada. Mr. A. B. Baker was engaged two months in making a

trip through northwestern Kansas, western Nebraska, and southwestern Dakota. One member of the office staff, Mr. Morris M. Green, visited the east coast of Florida, remaining there two months. Detailed reports of these explorations will appear later. In the present connection it need only be said that many hundreds of new localities have been added to the geographic ranges of species already known, that many species new to science have been discovered, and that an immense fund of information concerning the food-habits and economic relations of species has been brought together. The specimens collected, after being studied in the division, are deposited in the U. S. National Museum.

Dr. C. Hart Merriam, chief of the division, spent two months in a Biological Survey of the San Francisco Mountain region in north-central Arizona. This proved by far the most important work of the year, resulting in the discovery of many facts of great economic importance, as well as of much scientific interest. The discoveries of most economic consequence relate (1) to the recognition of a number of zones or areas possessing different physical and climatic conditions, and inhabited by different associations of animals and plants; and (2) to the correlation of these zones and areas with those of other localities known to be suited for the growth of particular kinds of crops. As a result of this survey a colored map has been prepared, on the scale of 4 miles to the inch, showing the boundaries of the several zones and areas in sufficient detail for the use of farmers and ranchmen. Timber maps also have been prepared, showing the distribution of the principal forest trees.

The result of most scientific interest is the overthrow of the "Great Central Province" of naturalists by the discovery that the life area heretofore recognized by that name consists merely of a somewhat modified northward extension of the fauna and flora of the Mexican plateau, penetrated by a southward intrusion of boreal forms along the Rocky Mountains.

BIRD MIGRATION.

I regret to state that nothing whatever has been done in the way of working up the vast fund of material on bird migration contributed by the voluntary observers of the division. Many thousands of schedules containing original records of migration are now in hand but can not be utilized, because no funds are available for the employment of an ornithologist to do the work, and the present force of the division is wholly occupied with the more urgent branches of investigation, branches which have a more immediate practical bearing on agriculture.

IDENTIFICATION OF SPECIMENS.

An incidental feature of the work of the division is the identification of natural history specimens sent here for that purpose by farmers and others throughout the country, as well as by the field agents of the division. During the year 1889 more than four thousand specimens were received and identified—a number very much larger than in any previous year. In identifying this material, and in answering the questions which usually accompany the specimens, much useful information is diffused among the people, and the division has come to be regarded as a public bureau of information.

SECTION OF ECONOMIC RELATIONS.

GOPHER INVESTIGATION.

NOTE.—The term Gopher is here used to designate the small mammals variously known as Pocket Gophers, Striped Gophers, Gray Gophers, and Spermophiles. They belong to two widely different families and are included in three genera, namely, *Geomys*, *Thomomys*, and *Spermophilus*.

The gopher investigation may be cited as an illustration of methods of inquiry and of the magnitude of the correspondence and other details of labor necessary in such researches. This inquiry includes, in the case of each of the numerous species concerned, the mapping of its geographic distribution, the nature and extent of the damage it does, the moneys expended in bounties for its scalps, and the methods employed for its destruction. It includes also a scientific study of the status of each species in relation to allied species.

The inquiry was begun in the summer of 1888, when a circular was prepared and distributed asking for information as to the kind and extent of damage done by gophers. More than one thousand one hundred letters on the subject were sent out in that year, and the replies indicated an evil of such magnitude that the investigation was continued during the present year by sending letters and circulars to parts of the country known or suspected to be infested with gophers. One set of these letters related mainly to the presence or absence of the animals, and to the areas inhabited by particular species. About one thousand two hundred and fifty such letters were sent to correspondents in twenty different States and Territories. In addition to these, letters were written to two hundred and sixteen county officers in Dakota, Iowa, and Minnesota, asking for data relating to the bounties paid or other money expended by these counties for the extermination of gophers. In most cases replies were received, further correspondence followed, and already a list of eighty-seven counties has been made in which such bounties have been paid, aggregating about $200,000.

The total correspondence on the gopher evil thus far amounts to two thousand seven hundred and twenty-eight letters or circular letters sent out, and one thousand four hundred and twelve reports received in reply. When it is remembered that hundreds of these letters were accompanied by skins or parts of skins of different species sent for identification, and that the distribution of each species has been provisionally mapped, some idea can be formed of the amount of labor involved in such investigations—and this does not take into account the technical comparison of specimens, including a critical study of their skulls and teeth, the summarizing and tabulating of final results, the collating of original and published records, and the preparation of final maps showing the position and extent of the area infested by each species.

THE ENGLISH SPARROW BULLETIN.

The first of the series of farmers' bulletins published by the division was issued in June, 1889. It treats of the English Sparrow in America, and forms a compact octavo volume of 405 pages. More than eight thousand copies have been distributed up to the end of the year.

Although so short a time has elapsed since its appearance, some of its good effects are visible already, and persons who have tested the recommendations for sparrow restriction and extermination have written the Department detailing their success.

HAWK AND OWL BULLETIN.

An important bulletin on Hawks and Owls is nearly ready for the printer. It treats of the geographic distribution, food, and habits of all the birds of prey which are known to inhabit North America north of Mexico. Of the diurnal kinds (the kites, hawks, falcons, and eagles) thirty-four species and eleven subspecies or geographical races are recognized; and of the nocturnal kinds (the owls) seventeen species and eleven subspecies, making a total of seventy-three.

The accounts of the food habits of the species of most economic importance are as exhaustive as the number of stomachs and the literature of the subject admit, and are accompanied by tables showing the kinds of food found in the many hundreds of stomachs examined.

The species have been arranged in the following categories (subspecies being included under the species to which they belong):

(*a*) Those which are wholly beneficial or wholly harmless (six species);

(*b*) Those which are mainly beneficial (thirty species);

(*c*) Those in which the beneficial and harmful qualities seem to balance each other (nine species);

(*d*) Those which are positively harmful (six species).

Three of the noxious species are of rare occurrence within the limits of the United States.

The bulletin is illustrated by many colored plates of both hawks and owls, and is one of the most important contributions ever made to the study of economic ornithology.

THE CROW.

In last year's report a preliminary study of the Crow was given, with the statement that a bulletin on this subject was in preparation. Work on this bulletin has been carried on as rapidly as possible, but lack of a sufficient number of Crow stomachs, together with the press of other work, has prevented its completion. The discovery made last year that the Crow was largely concerned in the distribution of the seeds of poison ivy (*Rhus toxicodendron*) and poison sumach (*Rhus venenata*) led to other interesting inquiries, and it was found that many other birds, including some of the most beneficial species (namely, bluebirds and woodpeckers), also feed largely on poison *Rhus* berries in winter and so doubtless aid in the spread of these noxious plants. It is probable that some good is done at the same time by planting valuable shrubs and trees, but the relative proportions of good and harm can be determined only after careful examination of the contents of numerous stomachs. In some cases these are already in hand and work on them has been commenced; in other cases they are yet to be collected.

THE CROW BLACKBIRD.

It is intended to issue a bulletin on the Crow Blackbird or Purple Grackle (*Quiscalus quiscula*) at an early date. A mass of data relating to the habits of blackbirds, and particularly to the above

species, was collected and partly arranged for publication two years ago, but so many interesting and important questions arose, particularly as to the food of the species, that it was thought best to defer publication until a sufficient number of stomachs could be collected and examined to settle positively some of the important questions at issue. Several hundred stomachs are now in hand and some of them have been examined, but stomachs taken during spring and early summer, as well as those taken in cornfields before the grain has hardened, are much needed still. It is hoped that these may be obtained during the coming season.

POTATO-BUG BIRDS.

Further attention has been given to the bird-enemies of the potato-bug or Colorado Beetle, and a few species beside the Rose-breasted Grosbeak have been found to eat the pest occasionally. Among these is the Yellow-billed Cuckoo, already known as a valuable friend of the farmer because of its habit of feeding upon caterpillars, both smooth and hairy. With the Grosbeak the habit of eating potato-bugs proves to be fairly constant, but unfortunately the bird does not seem to be very abundant anywhere, and hence the resulting benefits have not been generally noticed. Some of our correspondents have suggested that the scarcity of this bird and perhaps of others may be due to the habit of eating insects in places where Paris green has been used, but after careful inquiry we find no warrant for believing such to be the case. We have not been able to learn of a single instance in which any undomesticated bird has been found dead in the vicinity of potato fields under circumstances pointing to this cause. Birds certainly exercise much judgment in selecting their food, and it is not probable that they would eat sickly or dying insects so long as healthy ones were to be found.

SEED COLLECTION.

The importance of a complete reference collection of seeds for use in identifying the contents of bird stomachs becomes more evident every day. Although some additions to the existing collection have been made during the year, partly through the efforts of members of the division and partly through co-operation with the botanist, much still remains to be done.

COLLECTION OF BIRD STOMACHS.

The collection of bird stomachs has been increased during the year by the addition of eight hundred and seventy-two stomachs, and now numbers ten thousand seven hundred and sixteen. These are preserved in alcohol, mainly in separate vials. During the past two years this entire collection has been moved and re-arranged four separate times, each removal from one room or building to another resulting inevitably in more or less confusion, delay, and extra work. It is hoped that the new laboratory of the division where they are now arranged may prove ample, at least for those which are awaiting examination. Up to the present time it has been possible to examine finally only about two thousand of these stomachs, though the preliminary examination of about five hundred more has been made.

The economic work of the division is seriously hampered at present by the lack of funds to employ specialists to carry on the investigation, and one of its most urgent needs is a competent biologist to do this work—one familiar both with modern microscopical technique and practical systematic botany and zoology.

MARSH HAWK.

Circus hudsonius.

By Dr. A. K. Fisher.

This well-known hawk inhabits the whole of North America, breeding north to Alaska and the fur countries, and wintering from about latitude 40° N., south to Panama and Cuba. A representative species (*Circus cyaneus*) occurs throughout most of temperate Europe and Asia, wintering in the more southern portions as well as in northern Africa.

The Marsh Hawk breeds in suitable localities everywhere from the southern border of the United States to the northern limit of its range, being most common through the prairie country of the West. In the case of a species of such extended distribution the time of nesting is very variable. Thus while in Texas the eggs are to be found by the latter part of April, in the fur countries it is the middle of June before they are deposited.

The nest is always placed on the ground, usually in a marsh or prairie grown up with tall rushes, grass, or bushes, and not far from water. It is commonly situated at the base of a bush, or in localities subject to inundation, on the top of a tussock. It is composed chiefly of dry grass loosely thrown together and strengthened by the incorporation of a few dead sticks, and as a finishing touch a sparse lining of feathers is added. When the same site is used for several years in succession the accumulated mass of material often forms a platform of considerable size.

The number of eggs in a set is usually from four to six, though as many as eight have been found. As with most of the hawks, the period of incubation is about four weeks. The male assists the female in the construction of the nest, in incubating the eggs, and in procuring food for the young. During the period the young are being fed the male often drops the food to the female from a considerable height, as he passes near the nest, she darting upward and catching it before it reaches the ground.

This hawk is very zealous in protecting its young from intruders and has been known to attack persons or dogs who have entered its domain. After the young are reared and leave the nest they remain together, and as fall advances several families unite and migrate southward. Hence it is not unusual to see forty or fifty individuals at one time scattered over the more extensive marshes.

Though the flight of this hawk lacks the elegance of some of the other species, it is well sustained and often protracted. When the bird is beating back and forth over the meadows in search of food the flight is easy, regular, but not rapid, and resembles closely that of some of the herons. In the spring the male sometimes goes through a series of aërial evolutions which are highly amusing. While at a considerable altitude it throws its wings over its back,

and falling perpendicularly several yards turns over and over much like a tumbler pigeon until near the ground when it ascends rapidly again to repeat the performance.

When prey is discovered the hawk poises for a moment over the spot and then drops quickly on it, and if unsuccessful is sure to beat over the same place before leaving. It generally devours its quarry on or near the spot where captured, instead of carrying it away. Its food consists largely of small rodents, such as meadow mice, half-grown squirrels, rabbits, and spermophiles or ground squirrels. In fact, so extensively does it feed on the last-named animals that the writer rarely has examined a stomach from the West which did not contain their remains. In addition to the above it preys upon lizards, frogs, snakes, insects, and birds; of the latter, the smaller ground-dwelling species usually are taken. When hard pressed it is said to feed on offal and carrion; and in spring and fall, when water fowl are abundant, it occasionally preys upon the dead and wounded birds left by gunners. It seldom chases birds on the wing, though the writer has seen it do so in a few instances.

In speaking of the food of the Marsh Hawk, Audubon says:

> The food of the Marsh Hawk consists of insects of various kinds, especially crickets, of small lizards, frogs, snakes, birds, principally the smaller sorts, although it will attack partridges, plovers, and even green-winged teals, when urged by excessive hunger (Vol. IV, p. 400).

Mr. H. W. Henshaw, whose great field experience in the West enables him to speak authoritatively on the subject, says:

> They were seen at all hours of the day * * * in search of mice and gophers, which, when obtainable, constitute the major part of its food. When urged by hunger, it may attack birds; and I once remember to have been robbed of a widgeon I had killed and kept lying in the water, by one of these birds; but generally they confine their attacks to the humblest kind of game, which possesses neither the strength to enable them to resist nor the activity to evade the sudden descent of their winged enemy. (Ornith. 100 Merid., 1875, p. 416.)

Dr. Coues says:

> It ordinarily stoops to field mice, small reptiles, and insects. It is particularly fond of frogs. (Birds of the Northwest, p. 331.)

Mr. Ridgway, in the Ornithology of the Fortieth Parallel (p. 580), states that the stomachs and crops of specimens killed at Pyramid Lake were filled to their utmost capacity with the remains of small lizards, and nothing else.

Dr. B. H. Warren gives the following summary of his investigations on this species:

> In fourteen examinations made by myself, seven hawks had only field mice in their stomachs; three, frogs; two, small birds (warblers); one, a few feathers, apparently of a sparrow (*Melospiza*), and fragments of insects; one, a large number of grasshoppers with a small quantity of hair, undoubtedly that of a young rabbit. (Birds of Pennsylvania, 1888, p. 75.)

There is another way in which it protects crops, albeit unconsciously, as appears from the following:

> It is also said to be very serviceable in the Southern rice-fields in interrupting the devastations made by swarms of bobolinks. As it sails low and swiftly over the fields it keeps the flocks in perpetual fluctuation, and greatly interrupts their depredations. Wilson states that one marsh hawk was considered by the planters equal to several negroes for alarming the rice-birds. (Hist. N. A. Birds, Vol. III, p. 218.)

Dr. Merriam bears witness to the truth of the foregoing, for while at Georgetown, S. C., he saw an immense flock of bobolinks driven

from a field by one of these hawks which simply passed over at a considerable height, and made no movement to molest them.

Although this hawk occasionally carries off poultry and game birds, its economic value as a destroyer of mammal pests is so great that its slight irregularities should be pardoned. Unfortunately, however, the farmer and sportsman shoot it down at sight, regardless or ignorant of the fact that it preserves an immense quantity of grain, thousands of fruit trees, and innumerable nests of game birds by destroying the vermin which eat the grain, girdle the trees, and devour the eggs and young of the birds.

The Marsh Hawk is unquestionably one of the most beneficial as it is one of our most abundant hawks, and its presence and increase should be encouraged in every way possible, not only by protecting it by law, but by disseminating a knowledge of the benefits it confers. It is probably the most active and determined foe of meadow mice and ground squirrels, destroying greater numbers of these pests than any other species, and this fact alone should entitle it to protection even if it destroyed no other injurious animals.

COMMON SCREECH OWL.

Megascops asio.

By Dr. A. K. Fisher.

The little Screech Owls are distributed over the temperate parts of the globe and are among the better known of the owls. Their food consists of a great variety of animal life, including mammals, birds, reptiles, batrachians, fish, crustaceans, and insects. At nightfall they begin their rounds, inspecting the vicinity of farm houses, barns, and corn-cribs, making trips through the orchard and nurseries, gliding silently across the meadows or encircling the stacks of grain in search of mice and insects. Thousands upon thousands of mice of different kinds thus fall victims to their industry. Their economic relations therefore are of the greatest importance, particularly on account of the abundance of the species in many of the farming districts, and whoever destroys them through ignorance or prejudice should be severely condemned.

In winter many have noticed the tracks of mice which often form networks in the snow, crossing and recrossing, passing in and out of walls and stacks, or converging toward some choice bit of food—all tending to show how active these little rodents are during the period when most of the world sleeps. Occasionally a track stops abruptly, and while the observer is trying to read more of the history written in the snow, his eyes catch the faint impression of a pair of wing tips near where the trail ends, and instantly he is made aware that a tragedy has been enacted. Beside the different species of mice, the Screech Owls feed on other small mammals, as chipmunks, shrews, moles, and occasionally bats. During warm spells in winter they forage quite extensively and store up in their homes considerable quantities of food for use during inclement weather. It may be said in this connection that with one exception the only specimens of pine mice ever procured in southern New York by the writer were taken from the store-houses of these owls.

Frogs are devoured greedily, while other batrachians and small

reptiles are occasionally eaten. Crawfish are sometimes found among the stomach contents, but not so often as in the case of the barred owl. Evidence goes to show that at times this owl is an expert fisherman. Capt. Charles E. Bendire found it feeding on fish in the Northwest, and the following note by Mr. M. A. Frazer shows that it will sometimes travel a long distance for this food:

On November 29, 1876, I took from a Mottled Owl's hole (*Scops asio*), the hinder half of a woodcock (*Philohela minor*). Within two weeks after I took two owls from the same hole, and on the 19th of January last I had the good fortune to take another. After extracting the owl I put in my hand to see what else there was of interest, and found sixteen Horned Pouts (*Amiurus atrarius*), four of which were alive. When it occurred to me that all the ponds in the vicinity were under at least 2 feet of snow and ice, I could scarcely conjecture where the Horned Pouts could have been captured. After visiting all the ponds, I found they had most probably been captured in one fully a mile away, where some boys had been cutting holes through the ice to catch pickerel bait. The owl probably stationed himself by the edge of the hole and seized the fish as they came to the surface. What a busy time he must have had flying 32 miles after sixteen Horned Pouts. (Bulletin of the Nuttall Ornithological Club, Vol. II, No. 3, July, 1877, p. 80.)

Mr. Willard E. Treat, of East Hartford, Conn., speaking of this habit, says:

I secured a Screech Owl February 2, 1889, which was caught in a steel trap, the latter having been set in a spring where there were a number of small fish. When found it was dead, having been drowned, and its legs were more or less covered with fish scales. The trap was at least 4 or 5 inches below the surface of the water, which seems to show that the Owl must have plunged into the water in order to have got caught. This is the only instance in which I have known this species to enter the water for the purpose of securing fish. (The Auk, Vol. VI, 1889, p. 189.)

No species except the burrowing owl is so destructive to noxious insects as this; grasshoppers, crickets, and a number of night-flying beetles are devoured with relish. The stomachs of two young birds which had recently left the nest were found distended with May beetles. Prof. Samuel Aughey found remains of insects in all the specimens he examined in Nebraska, and states: "It is largely an insect-eating bird." Dr. B. H. Warren says: "During the summer months and at other times when insect life is abundant the Screech Owls subsist mainly on an insect diet." (Birds of Pennsylvania, 1888, p. 115.)

During the years 1884 and 1885, Mr. Charles Dury received at least sixteen specimens from the vicinity of Cincinnati; twelve of these, including one killed in January, contained remains of insects.

Writers almost universally speak of the Screech Owl as a beneficial species:

It preys on mice, small sparrows, etc., and very often catches nocturnal beetles and other insects. It thus destroys a large number of field-mice, and the large cockchafer, so injurious to our fruit trees. In winter it familiarly enters our barns and outhouses, where it becomes an expert and industrious mouser. (Dr. E. Michener, U. S. Agricultural Report, 1863, pp. 291, 292.)

The food is chiefly small quadrupeds, insects, and occasionally, when they have young, small birds. They destroy a vast number of mice, beetles, and vermin, and are of great service to the agriculturist. (Baird, Brewer & Ridgway, History of North American Birds, Vol. III, p. 57.)

After dark it is all alive; not a mouse can stir without being observed, and so quick and noiseless is the flight of the bird that few escape which expose themselves. (McIlwraith, Birds of Ontario, 1886, p. 158.)

A large number of castings of this species were examined on various occasions, and found to be composed almost entirely of the fur and bones of meadow and white-footed mice; with feathers of bluebird and some sparrow in several cases; and sometimes insects. (Mr. J. Percy Moore, in epist.)

Unfortunately we can not shut our eyes to the blacker pages of its history, and it must be said that occasionally it is destructive to small birds, especially during the breeding season when it has a number of hungry mouths to fill, and also in suburban districts where its favorite food is hard to procure. Mr. Morris M. Green found the remains of a house wren in a hole containing five young screech owls; and Nuttall says:

In the hollow stump of an apple tree, which contained a brood of these young owls, were found several bluebirds, blackbirds, and song sparrows, intended as a supply. (Land Birds, p. 121.)

Sometimes it kills birds fully as large as itself. In one of its holes the writer once found the remains of a quail; and a woodcock has been mentioned as found in a similar situation. In a few instances it has been known to kill and eat one of its own kind. When suffering from the pangs of hunger it occasionally attacks barnyard fowls.

About 3 o'clock on last Friday afternoon a common little Screech Owl flew into a large barnyard in this neighborhood and alighted on the back of a large hen, several times as large as itself, attempting to carry it off. The claws of the owl got entangled in the feathers of the frightened hen, and the owner of the farm was enabled to catch it. * * * There was scarcely any flesh on its bones and no signs of food in its stomach. (Night Hawk, Forest and Stream, Vol. xx, March 8, 1883, p. 106.)

Unfortunate as this bird-catching habit seems to be, it may be ranked as an important factor in the bird's favor. Since the introduction of the noxious English sparrow, and its alarming increase in our cities and villages, experience has taught the little Screech Owl that this sparrow is a delicate and easily obtainable food. Many times at dusk has this owl been seen hovering about the ivy mantled churches or thick shrubbery of the parks in search of sparrows, and still more positive evidence is furnished by the remains of English sparrows which have been found in the stomachs of owls shot in such localities.

This species breeds throughout its range, and does not migrate or even wander far during the winter months. It almost invariably nests in the hollows of trees, usually not over 10 feet from the ground; in inhabited sections old apple orchards are favorite resorts. Occasionally it has been known to breed in holes in buildings as well as in dove-cotes, but never in nests among the branches of trees, as is the habit of some other owls. Captain Bendire once found a pair of them breeding near Fort Walla Walla in the same tree with a pair of sparrow hawks, and there seemed to be perfect harmony between the birds although their holes were only about 2 feet apart. (Ornithologist and Oologist, Vol. VI, 1881, p. 21.)

In the following case noted by Mr. F. Stephens the relations of the species were somewhat strained. Mr. Stephens states:

On April 19, I heard a screaming noise proceeding from a woodpecker's hole in a pine. I climbed the tree, and pulled out a female McCall's Owl, and immediately after a male sparrow hawk flew out. The owl was apparently breeding, but the hole contained no eggs. (Bull. Nuttall Ornith. Club, Vol. III, 1878, p. 94.)

Evidently the hawk had been looking for a nesting site and had entered a tenanted one by mistake.

There never seems to be much of an attempt to form a nest; usually the cavity is incompletely lined with a few feathers from the parent bird, but this is by no means universal. The eggs, from three to six in number, are placed in the bottom of the cavity in the rotten wood and other material accidentally occurring there. In the South

they are deposited in the latter part of March, while in the more northern States full sets are rarely found before the middle of April. If the cavity is large enough the male usually remains with the female during the day while she is sitting on the eggs; if it is not of sufficient size to accommodate both, he may be found in a neighboring hole or copse. About one month elapses from the time the first egg is deposited until the young hatch, and these remain in the nest about the same length of time. Mr. F. H. Carpenter had a pair breed in confinement, and gives the length of incubation as twenty-two days. (Ornithologist and Oologist, Vol. VIII, 1883, pp. 93–94.) In the latter part of May or first of June, families composed of old and young sometimes may be started at dusk from the clumps of bushes bordering streams, or in the vicinity of old orchards.

The little Screech Owl is one of the most nocturnal of our species, seldom moving out of its retreat until twilight. Its flight is regular, and when indistinctly seen in the dusk it much resembles that of the woodcock. If suddenly started on a bright day it flies around in a bewildered manner but soon becomes accustomed to the light and apparently sees perfectly well. During the day it usually remains hidden in the hollows of trees or more rarely among the thick foliage. Here it is occasionally espied by some keen eyed songster in search of food. The little bird is not slow in making its discovery known to others in the neighborhood, who at the first note of alarm hurry to the spot. Soon an irritated mob, including perhaps a dozen species, surround poor *Megascops* and make life so uncomfortable that he is forced to seek another place, only to be followed and harassed by his tormentors. To escape these he chooses the dark cavities in hollow trees in preference to other and less secure hiding places.

During cold weather in the north it not unfrequently inhabits barns. Mr. McIlwraith, of Hamilton, Canada, states: "During some winters there is scarcely a farm in the country which has not its Screech Owl in the barn." (Birds of Ontario, 1886, p. 157.)

When kept in confinement the Screech Owl is one of the most interesting of pets, and although not so active on bright days as might be desired, it is usually so kind and affectionate as to fully compensate for its sluggishness. It soon learns to take food from the hand, and will allow a moderate amount of handling by its master. It is very fond of water and will drink or bathe eagerly when a fresh supply is placed in the cage. Once about dusk the writer came upon a small family which had emerged the moment before from the water. They were sitting on some low alders over a shallow portion of the stream, ruffling up and shaking the water from their feathers, and presented a soaked and forlorn appearance. Apparently they were too wet to be able to fly well, for when approached they fluttered off heavily into the thicket and soon escaped from sight in the growing darkness. The number of times this owl has been drowned in water barrels indicates its fondness for bathing. The following note by Mr. A. W. Anthony, of an incident in Washington Territory, unquestionably refers to a bird caught while attempting to bathe:

> One was caught in a steel trap set in a deep, narrow ditch. As the trap was sunk at least 4 inches under water, and was not baited, it is a puzzle to me how the bird was caught. (The Auk, Vol. III, p. 165.)

The low, wailing, moaning notes of this owl are not loud, but their character enables them to be heard a considerable distance; they sug-

gest, without resembling, those of the common dove. They may be heard at any time from dusk to dawn, and on rare occasions in the day-time.

The Common Screech Owl is distributed throughout the whole of the United States and southern portions of the British provinces. It is separable into several geographic races, as usual in species having a like extensive distribution. The typical form (*Megascops asio*) ranges from the eastern United States and British provinces south to about the thirty-fifth parallel and west to the Great Plains. The Florida Screech Owl (*Megascops asio floridanus*) inhabits the Gulf States from Louisiana to Florida, and extends north to South Carolina. The Texas Screech Owl (*Megascops asio mccallii*) is found in southern Texas and eastern Mexico and south to Guatemala. The Mexican Screech Owl (*Megascops asio trichopsis*) inhabits northwestern Mexico, Arizona, New Mexico, and Colorado. The California Screech Owl (*Megascops asio bendirei*) is limited to California. Kennicott's Screech Owl (*Megascops asio kennicottii*) inhabits the Northwest coast, from Oregon to Sitka, and east to northern Montana. The Rocky Mountain Screech Owl (*Megascops asio maxwelliæ*) is found in the higher Rocky Mountains, from Colorado to eastern Montana.

FLAMMULATED SCREECH OWL.

Megascops flammeolus.

This owl inhabits the highlands of Central America and Mexico, ranging northward into the United States as far as California and Colorado. It was first captured within our limits at Fort Crook, California, in August, 1860, and at the present time is one of the rarest owls in the United States. More specimens have been taken in Colorado than in all the other States, and so far this is the only region where it has been found breeding.

From the little that is known of its habits it is presumed that they do not differ in any marked degree from those of the Common Screech Owl. Its food also is probably the same, although the only data we have on this subject is the result of an examination, made by Dr. C. Hart Merriam, of the stomach contents of a specimen killed by him in the Grand Cañon of the Colorado, September 13, 1889. Its stomach contained one scorpion, some beetles, and a few other insects.

1/4

MARSH HAWK.

(Circus Hudsonius.)

Sackett & Wilhelms Litho Co. New York

SCREECH OWL.

(Megascops asio.)

Sackett & Wilhelms Litho Co. New York

REPORT OF THE BOTANIST.

U. S. DEPARTMENT OF AGRICULTURE,
BOTANICAL DIVISION,
Washington, D. C., January 4, 1890.

SIR: I have the pleasure to transmit herewith, for the Annual Report, a number of papers concerning the work of the Botanical Division.

Respectfully,

GEO. VASEY,
Botanist.

Hon. J. M. RUSK,
Secretary of Agriculture.

GENERAL STATEMENT.

RELATION OF BOTANY TO AGRICULTURE.

Agriculture is one of the oldest of the human occupations. For thousands of years the poor tillers of the soil have plodded along in a routine way, and in the meantime the very origin of most of the plants which they have cultivated has been forgotten. Very few of these plants now exist in the wild state, the greater part having been rescued from extinction by their continued employment in agriculture. The routine of the farmers' occupation is not productive of intellectual vigor, especially farm life that counts only the utmost employment of the muscular powers. The farmer should not be inferior in intelligence and education to other classes of human society. He needs to bring education to bear upon all the operations of husbandry. Almost every interest of farm life involves science in some form: geology in respect to the nature of the soil, chemistry in relation to plant food, entomology in the knowledge of beneficial or injurious insects, and botany in respect to the life, growth, cultivation, and improvement of the plants which engage his care and attention, as well as a knowledge of the diseases to which they are subject. Botany has special claims upon his attention. He should have an intimate acquaintance with the plants of agriculture, their history and relationships.

ADVANCE OF BOTANICAL SCIENCE.

Botany is one of the sciences which have made extraordinary progress during the past twenty years. Before that it had very little recognition even in our own best colleges. In academies and high schools it was taught in the most superficial manner, and the num-

ber of special students of botany were extremely few. A botanical laboratory for instruction in the vegetable tissues, their combinations and uses in plant structure, was then unknown. Now no college is well equipped without one. The science has shared in the general advancement of education. It has been greatly assisted by the formation of botanical societies and clubs, and by the publication of botanical periodicals. Another important agency in extending the science has been the organization of the agricultural colleges in this country. In these institutions it was early recognized that botany was one of the sciences which have practical relation to agriculture, and it became necessary to include it in the college course of study. There arose a demand for qualified teachers, and under this demand there has been developed a large number of instructors who have greatly improved the methods of teaching, have opened to the pupil new and interesting fields for investigation, and given new interest to the common objects of nature.

PURPOSE OF THE BOTANICAL DIVISION.

It is the purpose of the division to improve and elevate agriculture and to give it the benefit of scientific investigations in overcoming the enemies, especially vegetable, which the farmer encounters; to diffuse information respecting the many plants which are the subjects of agriculture; to teach how to make two blades of grass grow where one grew before; to investigate with reference to new and profitable kinds for culture, whether in the cotton fields, or in the wheat belt, in pastures and meadows, orchards, gardens, or vineyards. For purposes of this kind the division is open to the application of the humblest laborer, as well as to the thrifty farmer or the wealthy stock-grower. A new weed appears in the farmer's field or on his roadside; no one knows what it is or whence it came; the cattle become diseased or die from the effects of some unknown plant which they unsuspectingly eat on the mountain sides; application is made to the division; the plant is compared with its kindred in the herbarium and identified, and the question is solved. These are a few of the many ways in which the herbarium is of practical value. True, it contains thousands of plants which are entirely unknown to the public, and with which the public has perhaps no concern, but no one knows how soon the most obscure or insignificant plant may become a nuisance or a terror. Years ago a small parasitic plant was observed in the alfalfa fields of California. A few plants here and there did no harm, but soon they multiplied and spread; they wound themselves around the alfalfa stems and sucked its juices; they sent out their delicate threads in a network, and tied stalk to stalk for yards together, and sometimes they overran a whole field and bound the stalks together so firmly that the entire field might be shaken by pulling the stalks at one point. Botanical investigation showed that the destructive parasite was a species of dodder which had been introduced with the alfalfa seed from Chili. The farmers' crops are injured or destroyed by insects, or by the appearance of some fungous disease; his potatoes rot, his wheat rusts, his grapes mildew, his apples and pears blight, his oranges and other fruits are affected, and he spends his strength for naught. Then the scientist is called upon to investigate the nature and causes of the devastations and to devise some means to give relief.

USES OF THE HERBARIUM.

The fact that a botanist must understand a great deal about all kinds of plants is generally admitted, but as the use or necessity of a large herbarium in connection with practical botanical work is not so well understood, it may be worth while to say a few words on that subject. Were it possible to bring within the compass of these Department grounds, in a living condition, examples of all the different kinds of trees, shrubs, herbs, and other plants, high and low, which grow within the bounds of these United States; and if they were all the year long displaying their foliage, flowers, and fruits there would be comparatively little use for the herbarium, for the botanist could then study his plants from living examples. But ocean side, river banks, lake borders, dense forests, open prairies, dry plains, mountain plateau, alpine heights, and the greatest variety of climate, soil, and natural products can not thus be harmonized.

In a well equipped herbarium, however, examples sufficiently large for identification, of all our twelve thousand species of flowering plants and twice as many of the lower classes, may be securely stowed on its shelves and in its drawers, and be classified in such manner as to be convenient for examination and study at a moment's notice. The herbarium thus becomes a reference library, as indispensable for a naturalist as is a large library of books for the lawyer, statesman, clergyman, or physician. We glory in our great Library of Congress and spend millions of dollars in providing a suitable receptacle for it, because there all the literature of our own country and much of the literature of other countries is concentrated and made accessible, and that library is the resort of scholars and scientists from all parts of these States and Territories. All enlightened nations have established in their principal cities botanic gardens, national museums, and institutions of science, considering them to be indicative of their advancement in science and art.

In the city of London our English friends have what they call their Royal Herbarium, of which they are justly proud, for it is the largest in the world. There are represented not only every known plant of the kingdom, but all the known plants of their vast colonies in India, Africa, Australia, and America. It has been the custom of the nation to foster science; with their exploring squadrons they sent out scientists who brought home specimens of the productions of the countries which they visited or colonized. Collectors were sent into all the colonies; their vegetable productions were investigated, and specimens were collected and sent to the Kew Herbarium. These were elaborated and classified by the illustrious botanists connected with that herbarium. The material thus accumulated at headquarters made it possible for the British Government to publish its valuable colonial floras, as the flora of India, the South African flora, the flora of New Zealand, the flora of Australia, the flora of the British West Indies, etc., and finally enabled the accomplished botanists, Bentham and Hooker, to publish their Genera Plantarum, which is accepted as a handbook of the world's flora by botanists in all countries. The Botanical Division of this Department should be for this country what the Kew Herbarium and Museum is for England. Its opportunity for usefulness is expanding every day. Our vast country is becoming better known and more fully developed, new discoveries of plants

and other natural products are constantly being made, and a knowledge of these needs to be spread before the people, for popular information, by the Department.

EXPERIMENT GRASS STATION AT GARDEN CITY, KANS.

In the summer of 1886, under the direction of the Commissioner of Agriculture, the Botanist of the Department made an investigation of the grasses of the arid districts of Kansas, Nebraska, and eastern Colorado, with the object of ascertaining what were the prevailing species there, and to determine if any of them could be introduced into cultivation with the prospect of increasing the supply of pasturage in those districts. A report * of the investigation was published by the Department, from which we make the following quotations:

This region is bounded on the west by the Rocky Mountains and extends eastward to the one hundredth meridian, a distance of more than 300 miles. The elevation at the base of the mounains is about 5,500 to 6,000 feet. North of Colorado the mountain chain breaks down into the elevated Laramie Plains. This region is drained in the northern part by the Platte River, the north fork in Nebraska and the south fork in Colorado; by the Republican River in southern Nebraska; by the Smoky Hill in Kansas, and by the Arkansas and its branches in southern Colorado and Kansas. It is an immense, treeless plain, sloping eastward at the rate of about 10 feet to the mile. It is cut up in many places by dry channels called arroyas, which carry off the surface water and convey it to the larger streams. * * * There are some tracts of very sandy land, sometimes thrown into ridges and sometimes into small, shifting hillocks. But by far the larger part of this tract is a rich mixture of loam and clay, increasing in richness as we proceed eastward. * * * Near Denver, and northward on the Platte River and its branches, are some of the best agricultural lands of Colorado. They are irrigated by ditches and canals drawn from the mountain streams. In the southern part of the State the Arkansas River has been drawn upon for purposes of irrigation. But the irrigable lands constitute but a small part of the great plains. They are mostly elevated above the streams, and for a supply of water (other than the natural rain-fall), must depend upon wells and artificial reservoirs. The rain-fall over this region averages from 15 to 20 inches per year, increased occasionally in the southern part to 24 inches. * * *

Sufficient time has not elapsed to determine what will be the ultimate success of general agriculture in this section, but there can be no doubt that the country is eminently adapted to pastoral uses, and the settlers who are now filling up the country would do well to direct their efforts to stock-raising and dairy interests. * * * It has been argued that in this region agriculture can not be successful from a want of sufficient rain-fall, but it is now claimed by those residing on the soil that this is erroneous. It is said that in the natural condition of the soil the full benefit of the rain-fall is not obtained; that the ground is so densely packed that it is impervious to moisture, so that a large share of the rain-fall rapidly runs off into the arroyas and streams, as it would off a roof, whereas if the ground were plowed and pulverized a large part of the rain-fall would be retained. * * * Nature shows her willingness to respond to the ameliorating influences of cultivation. No sooner is the ground plowed and corn, sorghum, or millet planted than a crop many times as heavy as that of the native soil is produced. * * * And it is reasonable to expect that nature will be as ready to help in the production of perennial grasses as she is in the annual ones. There is every reason to expect that even the native Grama-grass may be made to double its yield by cultivation. But there is a considerable number of grasses native to that district which are more thrifty and productive than the Grama and Buffalo grasses, and if they were selected and sown upon properly prepared land there can be no doubt that a great improvement in the grass product would be effected. Indeed, we should extend our inquiries to foreign grasses cultivated in similar situations. But this is a question which can only be settled by experiment. Such grasses and forage plants require to be subjected to careful and protracted trials in order to obtain proof of their relative values under

* Bulletin No. 1, Botanical Division, Department of Agriculture. Report of an Investigation of the Grasses of the Arid Districts of Kansas, Nebraska, and Colorada. 1886.

different conditions of soil, moisture, and location. These experiments are difficult and expensive, and can not be made by private individuals; hence it is desirable that the Government should provide an experiment station in a central and characteristic location, where all the commonly cultivated grasses and forage plants, and also the most promising native ones. could be thoroughly tried under favorable conditions. This would be greatly in the interest of that large body of settlers who are now taking possession of the country, and who, without the aid of such information as could thus be obtained and communicated, will be exposed to many losses and disappointments in prosecuting agriculture under the peculiar circumstances here existing. A properly conducted and well continued series of experiments in this direction would result in discoveries of great value to the future residents of this arid district.

The statements and suggestions above quoted were made during the progress of the "boom" which induced thousands of poor men to rush onto the plains of Kansas and Colorado to try their fortunes in farming. The "boom" burst in the following year. A dry season occurred and the hopes of the farmers were blasted. Most of them had risked everything in the venture, and many were compelled to sell or abandon their lands or claims and seek employment elsewhere. This was especially the case in southwestern Kansas and the adjoining parts of Colorado.

At the session of Congress in 1887 an unsuccessful attempt was made to establish an experimental station; but at the next session, in 1888, provision was made for a station under the direction of the Commissioner of Agriculture. In August of that year a location at Garden City, in southwestern Kansas, was selected, that point being considered typical in soil and climate of a large region of surrounding country. The station is on the north bank of the Arkansas River, about 3 miles from the town. The object of the station was to make experiments with grasses and forage plants in order to ascertain what kinds were best adapted to culture in the arid districts. A public-spirited farmer, Mr. J. M. Jones, gave a free lease to the Government of 240 acres of level prairie land, lying about 40 feet above the level of the river. Prof. J. A. Sewall, of Denver, Colorado, a man thoroughly impressed with the importance of the work, and from experience well qualified for the undertaking, was appointed superintendent, and a beginning was made in September of that year. Eighty acres of the land were at once inclosed by a substantial wire fence. About 10 acres of the land had been broken and cultivated in previous years. This was now plowed thoroughly to the depth of a foot, and several plats of a few rods each were covered with sods of some six or eight kinds of native grasses collected in the vicinity. In the spring of the next year, 1889, a large number of grasses and forage plants, both native and foreign, were sown on the deeply plowed land, and were mulched with straw, chiefly for the purpose of preventing the action of the powerful winds which prevail there with such force as to sometimes sweep the seeds from the soil. The mulching had a good effect in protecting the surface, but an exceptionally bad effect in another direction. The straw had not been thrashed clean, and the seeds left therein dropped on the soil, germinated, stooled out, and threatened to smother the seeds which had been sown. Not only this, but it was discovered that the land had been full of foul weeds, and their successors sprang up in great abundance, and would have completed the ruin of the crops but for the expensive work of weeding by hand, which, although carefully performed, could not fail to remove some of the plants of the seed sown, so that the remaining crops were thin and had not a very satisfactory start. The sods that had been transplanted were

remarkably vigorous and productive. The principal native grasses sown were the following: *Agropyrum glaucum*, commonly called Colorado blue stem; *Andropogon furcatus*, commonly known as blue-joint; *Andropogon scoparius*, known here as wire bunch grass; *Chrysopogon nutans*, sometimes called wild oats; *Panicum virgatum*, sometimes called switch grass, and *Sporobolus cryptandrus*. About fifteen kinds of Indian grasses were sown, but almost wholly failed to germinate. Seeds from Europe were sown of meadow foxtail (*Alopecurus pratensis*), perennial rye grass (*Lolium perenne*), meadow fescue (*Festuca pratensis* and *F. elatior*), Hungarian brome grass (*Bromis inermis*), *Eleusine coracana*, *Trifolium incarnatum*, *Trifolium medium*, *Melilotus alba*, *Galega officinalis*, *Vicia villosa*, *Vicia hirsuta*, sainfoin (*Onobrychis sativa*), spurry (*Spergula arvensis*), and many others. Of these the perennial rye-grass, meadow fescue, spurry, Hungarian brome grass, and sainfoin were the most successful and promising at the end of the season.

In order to have feed for the teams employed, and to utilize and subdue the land, some 40 acres were broken and planted in several crops, as alfalfa alone, alfalfa with timothy grass and orchard grass, Johnson grass, and millet. These were irrigated from an adjoining ditch, made vigorous growth, and yielded large crops of hay, about 100 tons being put into stack. Another piece of land was planted with various kinds of sorghums, imphe, and Kaffir corn, and these without irrigation made a remarkable growth, some reaching a height of 10 feet. The Kaffir corn, although growing only about 6 feet high, produced the largest proportion of foliage (about 22 per per cent. of the entire plant), and was estimated to yield at the rate of more than 20 tons per acre. As might be expected, these experiments were attended with some failures and discouragements. But even the failures are instructive, for next to knowing what will succeed it is important to know what will not succeed. On the whole, the results of the experiments thus far are promising, although only a beginning has been made. The preparations for next year's experiments are extensive. The remaining 160 acres have been plowed aud fenced. About 40 acres have been sown to winter rye, which at the end of the season had made a very satisfactory growth. About 2,000 pounds of native grass seeds have been collected, with infinite labor and pains, and will be sown next spring. These will make fields of from 10 to 40 acres of some kinds. Several hundred pounds of foreign seeds have been imported, and it is believed that next season's experiments will give important results.

So important is the grass work considered that the Department has made arrangements with several of the experiment stations in the arid districts to co-operate with them in a series of experiments on grass and forage plants suitable for cultivation in such districts.

NOXIOUS WEEDS.

By F. V. Coville, Assistant Botanist.

The entire subjugation or extermination of the weeds here described can be secured only by perfect cultivation of the soil in which they grow. The required amount of cultivation is, however, too expensive, and certain indirect means of keeping out the weeds, or at least of preventing them from becoming too numerous, must be resorted to. In the case of annuals, since the plants die at the end

of the year, if, in addition, the seeds can be prevented from maturing, the remedy is easy. Although it is never possible in this way to kill every seed, so that there will be none to germinate, it is possible to greatly reduce the damage done by them. Of the weeds here described, charlock, stick-tight, mayweed, sow thistle, jimson-weed, and the thorny amaranth are annuals. In early summer they usually do not withstand the ordinary cultivation to which they are subjected. But in fence corners and out of the way places, and in fields after the crops are ripened, the weeds are commonly allowed to grow and mature their seeds unmolested. At this season mowing, burning, and plowing under, and that too before the seeds are ripe, are the best preventives that can be used. In the case of the perennials, hedge bindweed, yellow dock and bitter dock, the same method should be pursued, but it is ordinarily true of these plants that their seeds mature earlier in the season than do those of annuals, and their stronger roots enable them better to resist cultivation; and for this class of weeds the only remedy is constant cultivation.

ORDER CRUCIFERÆ.

Charlock (*Brassica Sinapistrum*).

[Plate I.]

An erect annual, commonly 2 to 3 feet high, branching above. Stems smooth, or with a few short stiff hairs; leaves of very irregular form, commonly from ovate to obovate, irregularly sinuate-toothed, the uppermost sessile and not lobed, the lower petioled and lyrately pinnatifid; flowers in long bractless racemes terminating the branches, on spreading pedicels ⅙ to ¼ inch long. Sepals 4, linear, ¼ inch long. Petals 4, the exserted, obovate, pale yellow limb ¼ inch long, on a claw of the same length. Stamens 6, 4, slightly exceeding the sepals, 2 a little shorter. Pistil slender, ovary with 2 parietal placentæ, 2-celled; style longer than the ovary, surmounted by a capitate stigma, the whole nearly equaling the longer stamens. Fruit, a capsule 1 to 2 inches long, slightly spreading, nearly cylindrical, tapering to an acute point, smooth, opening by 2 valves; valves splitting off from placenta to placenta, and from the base of the capsule to a point about two-thirds the distance to the apex, 3-nerved in addition to the marginal sutures; beak (part above the valves) empty or 1-seeded; seeds lying in a single row in the capsule.

A weed introduced from Europe, common in grain fields, especially in the northeastern United States, doing much damage by growing thickly over partly bare areas in early summer and choking out the grain that remains. The plants with which it is most liable to be confounded are yellow rocket (*Barbarea vulgaris**), black mustard (*Brassica nigra*), and white mustard (*Brassica alba*). The first may be identified readily by the comparatively many times shorter beak of the capsule; the second by its shorter, smaller capsule with one-nerved valves; the third, by its bristly—hairy capsule.

ORDER COMPOSITÆ.

Pitchforks (*Bidens frondosa*).

[Plate II.]

Plant annual, 2 to 6 feet high, erect, branching, nearly smooth, leaves opposite, petioled, pinnate; leaflets 3 to 5, lanceolate, acuminate, tapering into a short stalk below, coarsely serrate-dentate, sometimes reaching 5 inches in length. Heads terminating the branches, about ½ inch high, broad, and many flowered. Involucre in 2 series; the outer scales foliaceous, linear or oblanceolate, ciliate, exceeding the head; the inner thin, oblong, acute, shorter than the flowers. Ray-flowers none or inconspicuous. Disk-flowers all fertile. Pappus of 2 downwardly barbed awns. Achenia flattened, wedge-oblanceolate, somewhat upwardly scabrous, the 2 awns persistent and rigid.

* Plate XIX, Ann. Rep. Bot. Dept. of Agr., 1886.

The plant is a native of the United States, but grows precisely like an introduced weed. It is found throughout the country east of the plains, and is especially disagreeable on account of the awned and barbed achenia, which stick fast to any object that they can penetrate, very commonly to clothing and to the wool of sheep. By this means the achenia and the seed within are disseminated.

We have several other species of *Bidens*, all of which have similar backwardly barbed awns on the achenia, but the remaining characters given above will distinguish this species from the others.

BULL THISTLE (*Cnicus lanceolatus*).

[Plate III.]

Biennial; stem 2 to 4 feet high, usually much branched; leaves 6 inches long or less, lanceolate, bristly above, cobwebby beneath, pinnatifid, the lobes provided at the apex with very sharp stiff spines, sessile, the margins running down the stem into bristly ragged wings. Heads terminating the branches, about 1½ inches high just before expansion. Involucral bracts very numerous, imbricated, narrowly lanceolate, tapering into a slender spine-tipped apex; ray-flowers none; disk-flowers fertile, with pale red-purple corollas; pappus of copious plumose bristles.

This is the common thistle of Europe and has been naturalized throughout the country east of the plains. It is commonly found in pastures, but is by no means so persistent nor so troublesome a weed as the Canada thistle.* It is readily distinguished from that plant by its several times larger heads and the leaves bristly on the upper surface.

SOW THISTLE (*Sonchus oleraceus*).

[Plate IV.]

Plant annual, 1½ to 4 feet high. Stem simple up to the inflorescence, succulent, smooth, glaucous. Leaves flaccid, smooth, glaucous beneath, alternate, oblong in outline, deeply pinnatifid, the lower lobes horizontal, the terminal deltoid, all with acuminate-aristate irregular teeth, the lower leaves on margined petioles, the upper sessile with clasping base, the auricles usually acute. Heads about ½ inch high, many-flowered, in a bracted cyme sometimes leafy below, the peduncles occasionally somewhat glandular-hairy. Involucral scales narrowly linear-lanceolate, thin, a few of the outer ones shorter; receptacle naked. Flowers all with yellow ligulate corollas; pappus of very fine and soft copious white hairs, a few in each flower coarser. Achenia flattened, oblanceolate, beakless, striate.

This plant, with another closely allied European species (*S. asper*), is naturalized throughout the country. In *S. asper* the leaves are usually not lobed, sometimes slightly so, the auricle evenly rounded, and the teeth more numerous, longer and stiffer; the achenia oblong-obovate, 3 to 5 nerved on each side, smooth. These two weeds somewhat resemble several other plants (the thistles and the wild lettuces) of the order Compositæ, but may be distinguished by the characters given in the description.

MAYWEED (*Anthemis Cotula*).

[Plate V.]

Plant an annual; stem 1 to 2 feet high, sparingly cobwebby, either erect and simple below or with spreading branches at the base. Leaves numerous, alternate, commonly 1 to 2 inches long, twice or thrice pinnatifid, the ultimate segments short, linear, almost filiform, with a minute callous point, sparingly cobwebby.

* Plate VI, Ann. Rep. Bot. Dept. of Agr., 1886.

Heads terminating the branches, radiate; disk yellow, $\frac{1}{4}$ to $\frac{1}{3}$ inch in diameter, globular, or finally ovoid. Involucral scales somewhat imbricated, lanceolate-oblong, appressed, with membranaceous margins, and apex acute or obtuse. Receptacle lanceolate in outline. Flowers of the disk fertile, the upper ones subtended by slender chaffy bracts. Ray-flowers neutral, the ligule white, $\frac{1}{4}$ to $\frac{1}{3}$ inch long. Achenia oval-obovate, dirty yellow, about $\frac{3}{4}$ line long.

This weed has been introduced from Europe and is naturalized throughout the cultivated regions of the country, its particular place of growth being along roadsides, paths trodden by cattle, and pastures. It closely resembles a rather uncommon weed, also introduced, the field chamomile (*Anthemis arvensis*), but may be readily distinguished by the rank yarrow-like odor of its bruised herbage, by its neutral rays, and by the absence of chaff among the lower flowers. The chamomile is not rank-scented, has pistillate rays, and chaff throughout the head. In many parts of the West it is called dog fennel, or, to distinguish it from the yellow dog fennel (*Helenium tenuifolium*), white dog fennel.

ORDER CONVOLVULACEÆ.

HEDGE BINDWEED (*Convolvulus sepium*).

[Plate VI.]

Rootstocks slender, creeping, perennial; stems slender, few to several feet long, creeping or twining. Leaves alternate, scattered, long-petioled (commonly 1 to 2 inches), hastate, 1 to 3 inches long, tapering at the apex to an obtuse or acute point, the basal lobes acute or obtuse, sometimes with one or two large blunt teeth or lobes near the base, usually entire. Flowers single in the axils, on naked peduncles exceeding the leaves; the base of the flower closely invested by two opposite, sessile, ovate, foliaceous bracts $\frac{3}{4}$ to 1 inch long. Sepals 5, similar in form to the bracts, but smaller and of more delicate texture. Corolla open funnel-form, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, from white to rose-purple, the margin nearly entire. Stamens 5, inserted on the base of the corolla, included. Pistil 1; ovary 1 or 2 celled; style single, slender, included; stigmas 2, oblong, flat. Capsule included in the calyx and bracts, 4 seeded.

The plant is a native of our country, but is found as well in Europe, Asia, and elsewhere, widely scattered. It varies much in foliage, some forms being densely short-pubescent and with small narrow leaves. It is found in most districts east of the Rocky Mountains in moist situations along streams and fence-rows, and in cultivated fields and meadows. It creeps and twines over low bushes and walls, frequently causing much damage and much annoyance to farmers by twining about and choking field crops and grass. It closely resembles the morning glories (*Ipomœa*) and the common bindweed (*Convolvulus arvensis*), a plant not yet so widely naturalized in this country; but from both it may be distinguished by the presence of the pair of bracts at the base of the calyx.

ORDER SOLANCEÆ.

JIMSON WEED (*Datura Stramonium*).

[Plate VII.]

Annual; stem 3 to 6 feet high, smooth, branched from near the base, the branches spreading. Leaves alternate, petioled, ovate-oblong, coarsely and irregularly toothed or lobed, with acute or acuminate teeth and apex, smooth when mature. Flowers single in the forks of the branches, short peduncled, erect. Calyx tubular, $1\frac{1}{2}$ to 2 inches long, with 5 lanceolate acute teeth. Corolla 3 to 4 inches long, white, fun-

nel-shaped with a spreading 5 angular margin, the angles with short filiform points. Stamens 5, inserted near the base of the corolla; filaments long, but included. Pistil 1; ovary 4-celled, many-ovuled; style long, included, with 2 oblong stigmas. Fruit a stiff ovoid spiny capsule about 1½ inches long, provided at the base with a collar composed of the remains of the calyx. Seeds very numerous, kidney-shaped, pitted, ⅛ inch long.

The species is found throughout the country, but is especially abundant in the states east of the plains. It grows in cultivated fields, along roadsides, in fence corners, and various waste places. It is an introduced weed supposed to have come from Asia. Another species (*D. Tatula*), introduced from tropical America, has about the same distribution, but is in most districts less common. It differs by having the stem (which in *D. Stramonium* is green) purplish and the corolla pale purple. The common name is a corruption of Jamestown weed. It is also called thorn-apple and stramonium; and all three names, with "purple" prefixed, are applied to *D. Tatula.*

ORDER POLYGONACEÆ.

YELLOW DOCK (*Rumex crispus*).

[Plate VIII.]

Perennial; root single, thick, vertical, a foot or more long, tapering gradually below, almost without rootlets. Stem erect, 1 to 4 feet high or even taller, striate-angled, thick (sometimes ⅜ inch). Leaves narrowly oblong-lanceolate, tapering to base and apex, smooth or nearly so, the margins undulate, the radical and lower blades 3 to 9 inches in length and long-petioled, the upper shorter and becoming sessile. Flowers on slender recurved pedicels, jointed near the base, whorled along the branches of a contracted panicle 6 inches to 2 feet long, which is leafy-bracted below. Sepals 6, the 3 outer smaller, lanceolate, forced backward in fruit by the margins of the others; inner ovate, usually obtuse, enlarging in fruit and becoming somewhat heart-shaped, 1½ to 3 lines long, reticulate-veiny, entire or with minute teeth at the ends of the veins, one at least with a large grain-like body on the back. Stamens 6, not exceeding the sepals. Pistil 1, with 3 short styles and feathery stigmas; ovary 1-celled. Fruit an ovate, sharply triangular, smooth and shining, dark brown achenium or nut.

The plant is introduced from Europe and naturalized in most regions across the continent. It grows in lawns, meadows, pastures, and among field crops, its perennial root rendering it unusually difficult to extirpate. The wavy margins of the leaves have given rise to the specific name *crispus* and to the common name "curled dock" by which it is often known. The root is sometimes used medicinally, resembling rhubarb in chemical composition, and having tonic, astringent, and slightly laxative properties.

BITTER DOCK (*Rumex obtusifolius*).

[Plate IX.]

Plant closely related to *R. crispus*, but with the following differences: Leaves all petioled, oblong-ovate, the base obtuse or heart-shaped, the apex obtuse, not conspicuously undulate. Panicle slender, the whorls of flowers somewhat distant. Inner sepals deltoid-lanceolate, with 2 to 5 slender, weak teeth on each side near the base.

This species is about as widely naturalized as *R. crispus* and is of very similar habits. It may be distinguished by its broader leaves, slenderer panicle, and the teeth of the inner sepals. The veins of the leaves are often reddish. A hybrid between the two species is of frequent occurrence. It is characterized by leaves nearly those of *R. crispus*, and with the teeth of the sepals very much shortened.

ORDER AMARANTACEÆ.

THORNY AMARANTH (*Amarantus spinosus*).

[Plate X.]

Plant annual, erect, much branched, 1 to 3 feet high, smooth. Leaves alternate, ovate to lanceolate, sharply pointed, 1 to 3 inches long, on petioles of the same length, smooth on both sides; each leaf bearing in its axil 2 abruptly diverging, sharp, stiff spines about ⅛ inch long. Flowers greenish, small, in clusters in the axils of the leaves below, passing above at the ends of the branches into slender, flexuose, leafless spikes. Male flowers borne toward the apex of the spike; sepals 5, lanceolate, minutely aristate; petals none; stamens 5. Female flowers borne lower down, and similar; pistil 1, with 3 styles. Seed borne in a thin membranaceous bag or sac, lens-shaped, brown, shining, about ½ line in diameter.

This plant has been introduced into the United States from tropical America, and has spread throughout the middle and southern regions east of the plains. It is rarely found north of New Jersey, Pennsylvania, and Illinois. Its spines distinguish it at once from all of our other amaranths. It is essentially a southern weed, growing in out of the way places and to some extent in cultivated fields, the spines rendering its presence particularly disagreeable.

SHORTIA GALACIFOLIA.

A RARE AND INTERESTING PLANT OF THE MOUNTAINS OF NORTH AND SOUTH CAROLINA.

[Plate XI.]

In the year 1839 Dr. Asa Gray, while examining the herbarium of Michaux at Paris, came upon an unnamed plant, new to him, found, according to the label, in the mountains of Carolina. It was collected there by Michaux in 1788 during his travels in America. He had been unable to identify it with any species or even genus which he knew, and as the specimen was so incomplete (a fruiting one without flowers) he placed it undescribed among his unknown plants.

During an excursion made in that region in 1841 Dr. Gray was unable to find the plant, and in the report of the species collected on the trip he inserted a description of the specimen found in Michaux's herbarium. By reason of the special interest attached to the plant on account of its close relationship with certain others, some found only in eastern Asia, the remainder in eastern America, search was made by many collectors for this species, but to no avail. In 1877, however, the plant was accidentally rediscovered, this time in flower, by Mr. G. M. Hyams, on the banks of the Catawba River, near Marion, McDowell County, N. C., in the lower mountains of the Alleghanies. Not a great abundance of specimens was found, but a sufficient number to clearly settle the relationship of the plant, of which complete descriptions were then published by Dr. Gray.

Unfortunately the call for so rare a plant nearly or quite stripped this at that time the only known locality. Again *Shortia* bade fair to become an extinct plant with a finished history, but again it has come to light. In 1886 Dr. C. S. Sargent visited the headwaters of the Keowee, the eastern branch of the Savannah, and here following up, by means of Michaux's diary, the trail of another plant, he found *Shortia* in the very region in which Michaux had discovered it, in the high mountains of Carolina.

Since that time a local botanist, F. E. Boynton, has found that the plant occurs in the same region in inexhaustible quantities. The

particular locality, as described in a letter from Mr. Boynton, is on the White Water and Toxiway Rivers in South Carolina, from a short distance south of the North Carolina boundary down to the junction of these two rivers as the Keowee. It is very abundant on the little brooks that flow into the White Water.

The plant belongs to the order Diapensiaceæ, of which there are only three other species in the United States. It is well worthy of cultivation because of its intrinsic beauty, and its history makes it still more attractive. It has a slender creeping rootstock from the end of which rise a few long-petioled, oblong or orbicular, toothed, evergreen leaves; and a few slender peduncles, each bearing a single primrose-like flower about an inch in diameter, with toothed petals. It succeeds well in a half shady place, with a cool house in winter, in a mixture of two parts peat and one part loam. In its native region it flowers very early in spring, even before the trailing arbutus. Mr. Boynton collected it in full bloom in the latter part of March.

THE EXTERMINATION OF NUT GRASS.

The following is an abstract from an article published by the Hon. G. D. Tillman in a southern agricultural paper.

A figure and description of the nut grass (*Cyperus rotundus*), or coco, were published in the Annual Report of this Department for 1887 (p. 309, Pl. XIII).

The plan of campaign to extirpate nut grass is simply to prevent it maturing seed above ground. Nearly everybody thinks that the nuisance reproduces itself from the nut alone, whereas it propagates a thousand times more from the seed. Hence to effectually and quickly destroy nut grass on any land infested with it, the soil should be frequently stirred during the growing period of summer so as to stimulate each nut and seed to sprout and come up. It is a waste of effort to attack coco in winter, either by digging or plowing or turning hogs on it. The best time for fighting it is between midsummer and frost time, although myriads of the sprigs will show themselves above ground in a day or two after each working of the soil, even in the spring months, yet no seed-stem will shoot up till late in the season, and the secret of success, as before remarked, is merely to cut down every tall stem, while in the flowering stage at the latest, and the sooner the better.

The old method for destroying coco, by cutting it off under the surface of the ground every time a sprig appears above the surface is a useless expenditure of labor.

The ground should be often stirred with the plow or hoe, from April to frost, as before mentioned, to make every nut and seed come up if possible, and as soon as possible, but there is no urgent necessity, as far as eradicating the grass is concerned, to kill its sprigs until they begin to shoot up seed-stalks. For this purpose it is only requisite to plow up or chop down the grass at the regular intervals of working Indian corn, collards, or any other crop. Still it is advisable to plant the land in some tall-growing crop which shall neither cover nor obscure any coco seed-stem so as to prevent it being observed and destroyed.

By the above method two years are ample time in which to rid any ground of coco. In fact, one season is sufficient to eradicate it, except that a few scattering sprigs will show themselves in subsequent years, which can easily be prevented from going to seed by close attention. One cause that has enabled coco so long and so defiantly to hold its sway in the South is that we have so few crops which are hoed or plowed in the fall of the year. This, together with the popular error that coco propagates from the nut alone, explains the whole story of its universal triumph over the patience, sweat, curses, and blows of the millions who have warred on it.

It was further found by Mr. Tillman that the seeds of the nut-grass pass through the alimentary canal of horses with unimpaired vitality, and that manure from horses fed with nut-grass hay quickly seeded the ground on which it was used. This is an important fact, and means that nut-grass hay containing ripe seed should never be fed to stock.

FLORIDA PLANTS.

By J. H. Simpson, Manatee, Fla.

NOTES ON GRASSES.

Paspalum distichum, called joint grass, is common in Florida, and is generally found in low lands, though it is said to grow equally well on high ground. I have frequently found it growing along roads where other grasses had been exterminated. Mr. Reagan, of West Florida, says it grows on any kind of soil, and that drought does not affect it. It spreads very rapidly, rooting at every joint. It is a good grazing and lawn grass, and is easily transplanted. It is also a most valuable pasture grass.

Paspalum platycaule, called lawn grass or Louisiana grass, usually grows on low rich land, but is perfectly at home in poor pine land. As a pasture grass it can not be excelled, and is also an excellent lawn grass. No amount of grazing or trampling by stock will affect it. The more it is grazed and run over the more dense it becomes. The celebrated Miakka Valley, where thousands of head of stock are pastured all the time, is covered with this grass. Two years ago last June I examined it at the close of the dry season, and though it was cropped to its utmost extent, yet it was a perfect dense mat without a break or bare spot, although it had been grazed ever since the settlement of the country. It flourishes in my yard, which is a miserable quality of pine land. It will stand severe grazing during long droughts, and remain under water for weeks without injury.

Panicum Crus-galli, or barn yard grass. This grass produces immense crops of hay and can be cut twice a year, and then pastured until it dies. It should be cut while in blossom, as, if that be delayed until the seed ripens, the culms become woody. When once established it requires no seeding, but comes up every year of its own accord the same as crab-grass. Stock do better on it than on most other kinds of hay or fodder. I have it growing in poor pine land and the culms sometimes attain a height of 6 or 7 feet.

Panicum gibbum.—This most valuable grass seems to have been entirely overlooked as far as its qualities for hay and pasturage are concerned. It usually grows in wet places with culms 2 to 3 feet high, but I have seen specimens that measured more than 5 feet. The late J. H. Harris, of Braidentown, informed me that he believed he could mow from 3 to 5 tons per acre of the most excellent hay, and that it was also an excellent pasture grass. He had experimented with it for years, and was satisfied that it was a valuable grass for hay and pasture.

Panicum sanguinale, the common crab grass or finger grass. This is a nutritious and valuable grass for hay. The great trouble for hay in Florida is, that it is not ready to mow till after the rainy season sets it, when it is almost impossible to cure it. It makes excellent pasture until it dies down.

Panicum virgatum.—This would undoubtedly be a valuable grass for hay in Florida, as it so nearly resembles the cultivated Guinea grass which is so highly prized for hay. Could it be set close together in a damp meadow, so as to make a good stand, the yield of hay would certainly be immense.

Setaria macrostachya, or pigeon grass. This is a wild species of

millet, resembling Hungarian grass. It grows tall, frequently 6 feet high, with erect spikes. It grows in low lands and is also perfectly at home on the poorest pine land. It should be cut early to make good hay.

Andropogon provincialis, blue joint. This is one of the grasses known for hay. It is also good for pasture as long as it lasts, but in a few years stock will kill it by continual grazing and trampling. It is equal to the best tame hay known. Having mowed, handled, and fed many tons of it for seven or eight years I know whereof I affirm. All the andropogons in the State I am satisfied would be valuable for hay.

Cynodon Dactylon, Bermuda or scutch grass. I consider this the best lawn grass for this region. It is perfectly at home in the poorest pine land, forming a dense sward that is there to stay. Care should be taken to plant it in pasture or lawn only where it is intended that it should remain, as it is difficult to eradicate it. It is a most excellent pasture grass, and seems to be adapted to the dry sandy soil of Florida.

Panicum Curtisii, commonly called maiden cane. It has been stated that this species never bloomed, and that specimens with hairy sheaths were distinct from those with smooth sheaths. I have ascertained that where the land is wet and rich enough so that it has sufficient vitality to produce both root-stocks for the next year and culms for the present year, it does bloom; but when the land is so dry and poor that it can not produce both, it will produce the root-stocks alone, and in that case will not bloom. I have ascertained that the specimens with hairy sheaths are from the same plant as that with smooth sheaths. It is likely to prove a valuable forage grass.

OTHER PLANTS.

Nuphar sagittæfolia Pursh (a species of pond lily), I found quite common in De Soto County, and sparsely in the Miakka River. Dr. Chapman credits it to "Georgia to North Carolina," and wrote to me that he had not heard of its growing in Florida. (It has been collected in Santa Rosa County by Mr. A. H. Curtiss.)

Gordonia lasianthus L. (the loblolly bay), grows to be a tree 50 to 80 feet high, yet begins to bloom when only 3 or 4 feet high, continuing to bloom every day for several weeks in succession.

A species of cotton (*Gossypium hirsutum*, perhaps), is a naturalized shrub or tree in this section, sometimes attaining a height of 20 feet, with a diameter of 1 foot. It grows in the woods long distances from cultivation; indeed, I have known of no cotton being raised in this section. Rev. Edmund Lee, of Manatee, Fla., told me that twenty-two years ago a party of movers camped in a lot belonging to him. The women of the party picked over some sea-island cotton, throwing the seed on the ground. This sprang up and grew, and has been continued in propagation ever since. I have seen them in all stages of growth from a foot high to small trees.

The genus *Vitis* is remarkable in this section for the very few fertile vines found. I suppose of those growing in their native habitat not more than one vine in a hundred is fertile. *Vitis Simpsoni* Munson is the second most common species we have, growing in great profusion in the hummocks, especially the low hummocks. I have seen hundreds of them, and yet I have only found five bearing vines and they bear but a few grapes. Of *Vitis coriacea* Shutt, I

have found six bearing vines, and three or four of its hybrids that were bearing. Of the Florida form of *Vitis æstivalis* (which is without doubt a distinct species), I have found six bearing vines. Of *Vitis vulpina* I have found only one bearing vine. The *Vitis Munsoniana* J. H. S. is a very peculiar species. It is by far the most common species we have. Its native habitat is in the hummocks, where probably not one vine in five hundred is a bearing one. It is also abundantly found along the fences, around stumps, and in waste grounds in poor pine lands. These vines have come from seeds dropped by birds, as they are out of their natural habitat. The strange part is that while the vines which grow in hummocks are nearly all sterile, yet those that spring up in poor pine lands, along fences, and around stumps are largely bearing vines, probably one-half of them or more. The leaves of many of the vines remain on all winter, turning red, yellow, and the various autumnal tints that leaves assume in a northern forest. Rarely, the leaves remain green all winter, especially south of this place. Several of the bearing vines of this species are ever-blooming; that is, they bloom at intervals from April to October, but as the stamens of the fertile flowers are short and declined, the pollen fails to fertilize the stigmas; in consequence, they only set one crop (or rarely a second one) fertilized by the pollen of the latest blooming sterile flowers. Botanists have usually described *Ampelopsis bipinnata* Mx., as destitute of tendrils. Linnæus seems to have been of this opinion when he named it *Vitis arborea*. Here, however, it has a full supply of once-forked tendrils the same as any species of *Vitis*. I never saw a vine of it but what had its intermittent forked tendrils the same as the highest species of *Vitis*.

Cissus incisa and *Cissus sicyoides* L. bloom abundantly in this section, but never set fruit. I have had both species in cultivation in my yard for years, but have never seen a berry either in the wild or cultivated state.

Indigofera tinctoria L., wild indigo, is described as being herbaceous. For three years this plant has continued growing, blooming, and producing seed on my grounds, and has become a shrub. It will probably continue to grow until killed by frost.

Erythrina herbacea L. is described, as its name indicates, as being herbaceous. Here it is a shrub or tree. On Terraceia Island, near the mouth of Tampa Bay, where the soil is very rich and frost seldom occurs, it grows to be a tree 30 feet high, as I have been informed by a reliable botanist. At Cedar Key I found it to be a shrub 3 or 4 feet high.

Chapmania floridana T. and G., a leguminous plant, is a morning bloomer, withering and closing about 8 or 9 o'clock a. m., when the sun shines, or a little later when cloudy.

*Jussiæa erecta** L. I have found growing in two or three places in Manatee. It varies greatly in size, from a simple-stemmed plant of a few inches in height to a tall branching one several feet high, and always grows on dry land. The tallest one I saw was 9½ feet high and began to branch 2 inches from the ground. It is an annual, and begins to bloom when but a few inches high. The flowers are small and the petals caducous.

The *Citrillus vulgaris* Schrad. (watermelon) is naturalized along the Manatee River. Some years ago I followed down the north side

* J. acuminata, Sw.

of the river below Palmetto. For a distance of probably 2 miles I found watermelon vines growing in the channel of the river every few rods. They were growing in pure sand so close to the salt water that it looked as if they must have been wholly or partly submerged at high tide. All along the bank of the river where these vines grew it was primitive forest. None of the land was cleared or cultivated, and not a habitation in sight on that side of the river. Watermelon vines are spontaneous on my place, springing up where I have never dropped a seed, those from which the vines came having perhaps been carried by rats. Strange to say, though I have often planted seed on the same lot, not one of them ever ripened a melon, while the volunteer ones bore fine fruit, one of them weighing 28 pounds.

Opuntia tuna Mill., a prickly pear, is rarely mentioned in our botanies, though it is common along the coast. It produces large, obovate joints, and long stiff spines, so that I have had them penetrate my boots while walking among them. It is many times larger than the *Opuntia vulgaris* which is so common in pine land. Sometimes, but rarely, it is found in hummocks some distance from the coast.

Psidium Guaiava Raddi, the guava plant, seems to have been overlooked as a naturalized shrub in Florida. Dr. Chapman, in the Supplement to the Southern Flora, says it is cultivated at Manatee, and occurs along the west coast of Florida. There are thousands of these shrubs growing wild all over this section of the State. They grow so thickly in some places along the streets of Manatee that they hide from view the fences, and the spontaneous ones usually do better than those that are planted.

Sambucus Canadensis L., the elder bush, which is only a shrub in the Northern States, often becomes a tree in south Florida. One of my neighbors has a tree of this species that is 13 or 14 inches in diameter.

Helianthus littoralis Chap., a wild sunflower, is a new species which has been confounded with *H. floridanus* Gray. The new species is a perennial, with tuberous roots, stems slender, rough, covered with short rather stiff hairs, simple, 2 to 2½ feet high; leaves lanceolate, rough, 1-veined, sessile, margins revolute, entire, rounded at the base, 1 to 1½ inches long, 3 to 4 lines wide, close together on the stem; stems generally with a single head, sometimes corymbosely branched near the summit, the branches terminated by a solitary head; heads 6 to 9 lines in diameter; disk yellow; rays about 10, an inch long, narrow; scales lanceolate, acute, spreading, in about 4 rows. Plant begins blooming in May or June and blooms for several months. It does not exude a resinous gum when bruised.

Ulmus Americana L., the American elm, is found in Manatee County, but instead of being the large magnificent tree that it is in the North, it is a mere pigmy. The largest specimens I have seen in this section are not more than 25 or 30 feet high and 5 or 6 inches in diameter.

The genus *Smilax* is a most difficult one as here found. There are nine species in this county, and the identification of most of them is little better than guess-work. Dr. Chapman and Professor Darby say that the berries of *Smilax pumila* Walt. are white or whitish. Professor Wood says they are red, and he is correct so far as I have observed, for in every instance I have found them red.

Vittaria lineata Swz. is a remarkable epiphytic fern. Its long,

narrow, grass-like fronds look far more like an endogen than anything else, at first sight. I have seen the fronds 2 to $2\frac{1}{2}$ feet long, and not more than 2 or 3 lines wide.

Nephrolepis exaltata Schott, grows either as an epiphyte on trees, or more commonly here in deep shady woods in the rich leaf mold among the trees. It grew very abundantly along a ditch in poor pine land where it was entirely exposed to the sun in the village of Manatee; so it appears to be perfectly at home as an epiphyte, or growing in dense shade in leaf mold in the ground, or in poor pine land fully exposed to the sun.

UNIOLA PALMERI.

A NEW GRASS OF ECONOMIC IMPORTANCE.

In 1885 Dr. Edward Palmer collected, near the mouth of the Colorado River, some specimens of a grass from which he said the Cocopa Indians obtained the seeds in large quantities and used them as food. At the time he was there the grass was out of flower; he found only a few disconnected spikelets, and the botanical characters could not well be determined. In April of the present year Dr. Palmer, being employed by the Department of Agriculture to make botanical investigations, made another visit to the locality and obtained in that region specimens in good condition, enabling me to locate the plant botanically. As the genus Uniola is defined by Bentham & Hooker, our grass must be considered as of that genus. Its general appearance and habit is that of Distichlis, from which it differs in having four of the lower glumes (instead of two only) in each spikelet empty, *i. e.*, without palet or flower, and in the disarticulation of the rhachis between the spikelets of both sexes—that is, the spikelets break apart between the several flowers when mature. This disarticulation occurs also to some extent in the fertile spikes of Distichlis, but not in the male or infertile ones. On the other hand it differs from Uniola in its diœcious character, and here agrees with Distichlis. It seems in fact to connect these two genera, but so long as the two are kept distinct it must stand as Uniola. Specifically it is new, and I have given it the name of *U. Palmeri*.

The following notes I collect from Dr. Palmer's letter:

The specimens were collected at the Horseshoe Bend of the Colorado River, 35 miles south of Lerdo by the river, and 12 to 15 miles from its mouth. This is the most extensive locality of the grass, thence extending down to the mouth of the river. It covers a space of from 1 to 20 miles wide, and occurs on both sides of the river. It is estimated that there are from 40,000 to 50,000 acres covered with this grass. It grows from 2 to 4 feet high, from strong, deep root-stocks, frequently many culms from the same root. The stems are covered to the top with the sharp, stiff leaves. The sterile plant grows more or less mixed with the other, but at times in masses entirely by itself. Dr. Palmer noticed several forms. One of these is more slender, with the leaves shorter, more numerous, and more finely pointed. This, he says, grows on land that has but little overflow. Where, by changes in the river, any patches are left above tide-water, they soon die.

The Indians come together here at the proper season, in April, and gather this, to them, important article of food. As its quantity depends on the overflow of the tides, and the tides are sure to occur, they have an assured crop without any other labor than gathering and caring for the grain. The gatherers enter the fields as soon as the tides have entirely run off, where the soil is an adhesive clay so soft that the Indians often sink nearly to their knees in gathering the grass, and as soon as the tide begins to flow they return with the result of their labor to their camps. It is quite difficult to pull up the plant by the roots, as these are often two to four feet long, but the stems are brittle and easily break off above the root. The Indians, in harvesting, use any old knife, or if they have none they take a flat piece of wood and form an edge on each side, and with this they sever the stems, the left hand grasping the tops, which are then thrown into a basket. The rigid, spiny-pointed leaves make the process a painful one. The grain has to be cut when a little green, because of the easy separation of the spikelets. In order to dry the heads as quickly as possible, large fires are made, and the heads are piled around so that the flames penetrate between them. When they have been sufficiently exposed to the fire a stick is used to thrash the heads, which breaks up the spikelets, but does not separate the chaff or glumes from the grain. The dried and dissevered spikelets are then taken to a piece of ground prepared for the purpose, and the Indians tread upon and rub the grain between their feet until the seeds are shelled out.

This process is more easily accomplished after the grain has been exposed a while to the sun, but in any case it is pretty trying to the feet because of the sharp, stiff points of the chaff. The action of the tide knocks off and carries away considerable of the grain, but this is left in rows at the edge of the contiguous dry land, and the Indians gather much of it and rub it out. They have to be expeditious in their harvest, as wind storms are liable to arise and destroy or injure the product of their labors.

Dr. Palmer was accompanied on his trip by two gentlemen connected with the U. S. Fish Commission, who took photographs of the grain field, and of the thrashing and treading out of the seed from the chaff.

It is not yet ascertained how far up the river this grass extends, but probably to the limit of tide-water, and in this case it will yet be found within our boundaries. The related *Distichlis maritima* grows not only on the sea-coast, but in nearly all saline and alkaline grounds in the interior of the country, but we can not infer from that fact that this species might be cultivated outside of the reach of the tides.

USEFUL DESERT PLANTS.

The southwestern portion of the United States, embracing western Texas, New Mexico, Arizona, and southern California, constitutes what may be called the desert belt. In this stretch of country there are many mountain ranges, with numerous high peaks, whose sides are covered with timber, and their bases covered with grass and supporting thousands of cattle and sheep. But a great portion of the country possesses many of the natural features of the northern portion of the African Sahara. Several years ago Mr. Melivier, a member of the Acclimation Society of France, visited Mexico and our

southwestern borders in order to study the vegetation of the arid and desert regions. He was struck by the similarity of climate between this region and southern Algiers. In his report he states that he found a large desert belt, extremely dry, with winters of copious rains, with such intense solar radiation and dryness of air as to cause enormous variations of temperature and humidity. Nothwithstanding these conditions, so unfavorable for richness of vegetation, he found that there was a greater element of utility in the native productions of this country, and that several of the wild plants might with benefit be introduced into the Algerian Desert. Among these plants he mentions the mesquite and screw bean, the cactus fruits, the different agaves and yuccas, and the nut pine. In some places he found a considerable Indian population of good physical development, who obtained their subsistence largely from the plants native to the country, which furnished them edible grains, sweet fruits, alcoholic drinks, and useful fibers. The observations of Mr. Melivier are extremely interesting, but we only allude to them here in order to draw some attention to the possibility of an extensive practical utilization of the native desert productions. One of the most widely diffused plants of the desert region is the prickly pear or cactus in many forms. In some parts of western Texas cattle-men have learned to utilize these plants in feeding and fattening domestic animals. They produce abundantly a pulpy fruit which is not palatable, but the plants are essentially like the "tunas" of Mexico, which furnish a rich saccharine and nutritious pulp, and these valuable varieties can easily be substituted for the wild ones. In Arizona and southern California the tree cactus, or *Cereus giganteus*, and several related kinds furnish pulpy fruits, which form an important article of Indian food, and a proper selection and cultivation of the best varieties of these might be made useful and profitable. Next to the cactus family, the various kinds of yuccas and agaves form a striking feature of vegetation, and many of them are utilized by the native inhabitants for food and for fibers. Some of these have a pulpy, edible fruit, and most of them furnish a mass of condensed foliage, which in the young state is roasted and eaten with great relish and is an unfailing resource in time of scarcity of other food.

One of the most widely diffused plants of the arid belt is the mesquite tree or bush. This produces two crops per year of beans, which have a high value as feed for stock. The aborigines of the country made great use of these beans as an article of food. The production of this desert fruit might be developed to any extent desired. Another desert product having great prospective value is a root called canaigre, or botanically *Rumex hymenosepalus*. The root contains a large percentage of tannic acid, and it is being employed in tanning leather. If it were brought under cultivation it could be raised in great quantities and with much profit. It is also reputed to have medicinal properties analogous to those of Turkey rhubarb. The common creosote bush of the desert (*Larrea Mexicana*) furnishes a gum which is a good substitute for the shellac of commerce. The mesquite bush, in addition to the value of its beans, also produces a gum which is an excellent substitute for the gum arabic of commerce.

The above-named plants are among those which may be utilized without irrigation. When we come to add the influence of an artificial supply of water, there is scarcely any product of semi-tropical countries which can not be abundantly produced.

LIST OF PLATES.

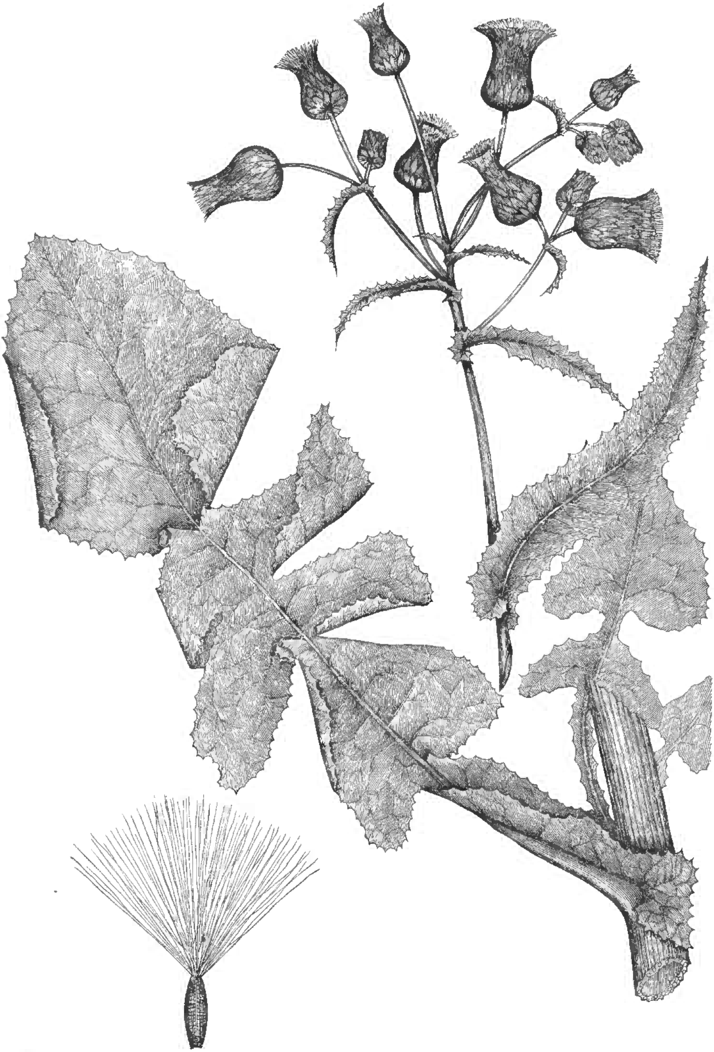
REPORT OF THE BOTANIST.

L R. Stowell del.

BRASSICA SINAPISTRUM (CHARLOCK).

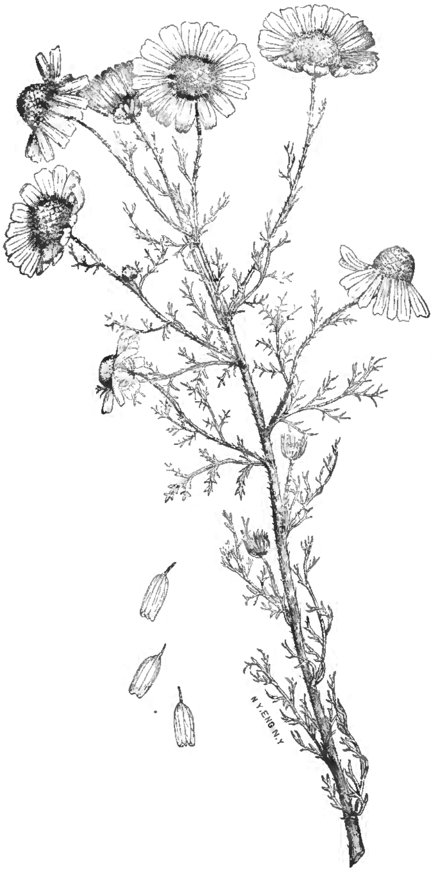
BIDENS FRONDOSA (PITCHFORKS).

CNICUS LANCEOLATUS (BULL THISTLE).



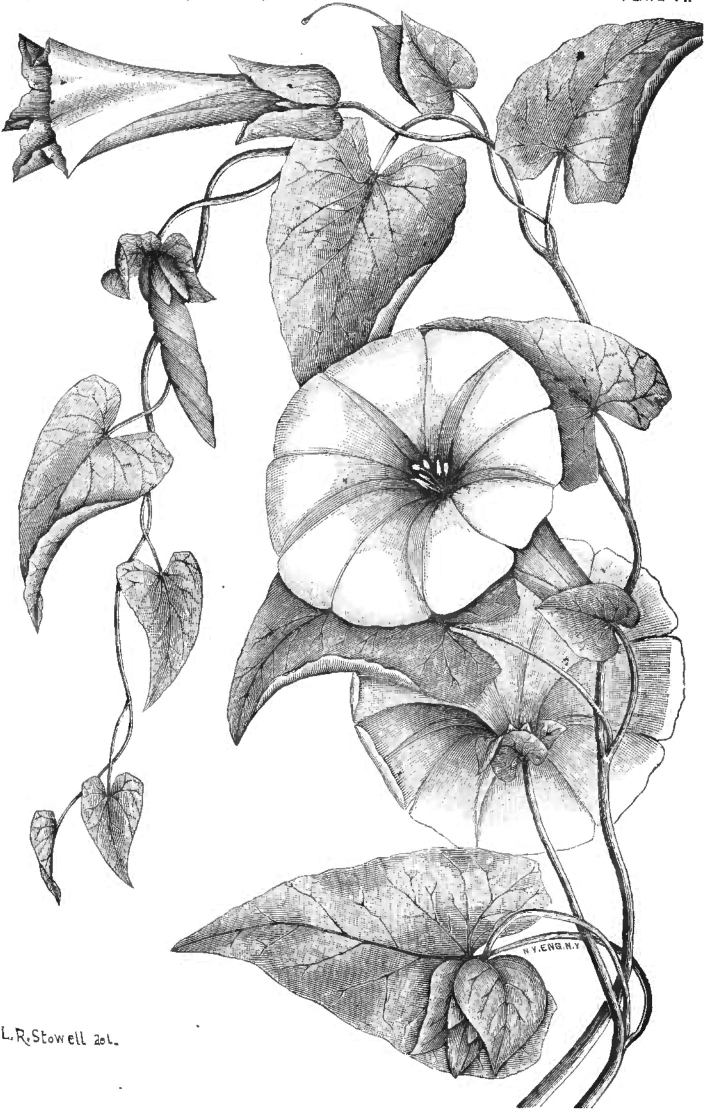
E. STOWELL, DEL.

SONCHUS OLERACEUS (SOW THISTLE).



L.R.Stowell del.

ANTHEMIS COTULA (MAYWEED).

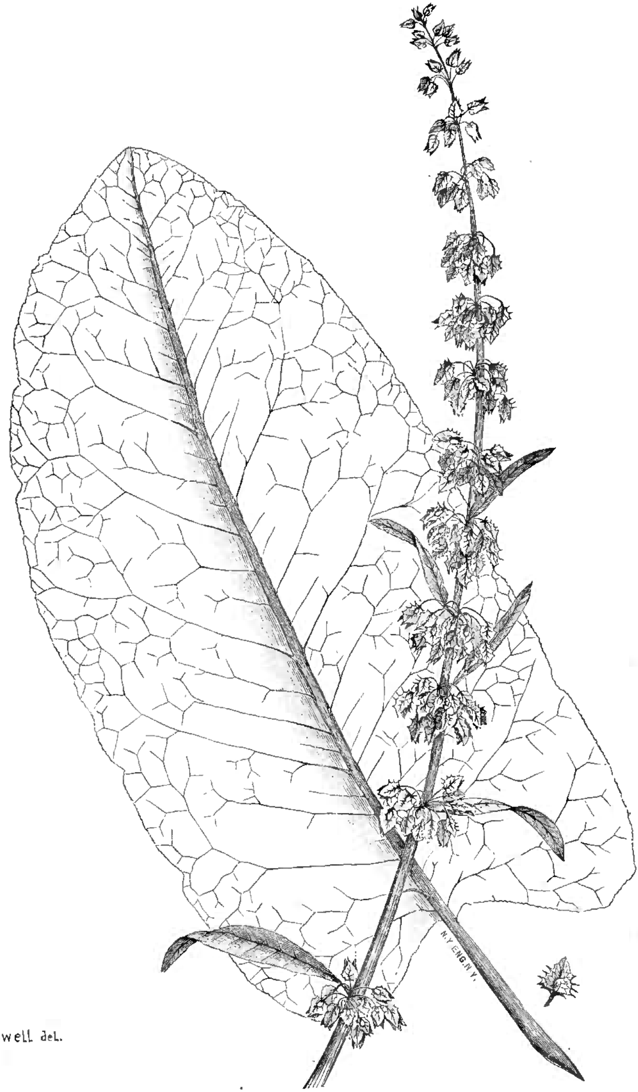


CONVOLVULUS SEPIUM (HEDGE BINDWEED).

DATURA STRAMONIUM (JIMSON WEED).

L. R. Stowell del.

RUMEX CRISPUS (YELLOW DOCK).



L. R. Stowell del.

RUMEX OBTUSIFOLIUS (BITTER DOCK).

L. R. Stowell del.

AMARANTUS SPINOSUS (THORNY AMARANTH).

SHORTIA GALACIFOLIA.

REPORT OF THE SECTION OF VEGETABLE PATHOLOGY.

SIR: I have the honor to submit herewith my report on the work of the Section during the past year. No attempt has been made to give the details of any particular investigation, these being left for publication either in the QUARTERLY JOURNAL or in special bulletins which are being issued from time to time.

Respectfully,

B. T. GALLOWAY,
Chief of the Section.

Hon J. M. RUSK,
Secretary.

I.—PUBLICATIONS AND CORRESPONDENCE.

During the year the Section has issued at regular intervals, under the title of THE JOURNAL OF MYCOLOGY, four bulletins, the first number having been distributed in April. Each number contains on an average about fifty pages and is illustrated by from two to four plates with additional figures in the text. The JOURNAL is specially designed to aid experiment-station workers and others engaged in the study of fungi, many of whom do not have access to the constantly increasing literature on the subject.

Being the only strictly mycological publication in the country, its pages are open to all workers in this branch of science who may have anything of value to contribute. In each number an effort is made to bring together brief reviews and abstracts of the important current literature, special attention being given to foreign publications in order that our workers may know what is being done in other countries. Some of the more practical subjects discussed in the recent numbers are: (1) Treatment of apple scab, by Prof. E. S. Goff, of the Wisconsin Experiment Station; (2) treatment of potato rot, by Clarence M. Weed, of the Ohio station; (3) peach rot and blight, by Dr. Erwin F. Smith, etc.

The JOURNAL is distributed among botanists of all countries, and the hearty reception it has met with everywhere, together with the constantly increasing demand for it, is, we believe, sufficient proof of its value.

Bulletin No. 9, on Peach Yellows, which was referred to in my last report, was issued in March, and the whole edition of 5,000 was practically exhausted in less than a month.

There have been nearly two thousand five hundred applications for this bulletin in excess of the edition, and the plates used in illustrating it have been purchased by a number of horticultural societies, their plan being to publish extracts from it in their annual reports.

In this way important information contained in the bulletin will reach many who do not have access to it.

Bulletin No. 10, a report on the experiments made in 1888 in the treatment of the downy mildew and black-rot of the grape vine, was issued early in the season. In many respects this is the most important publication yet sent out by the Section, as it contains an account of the first successful treatment of black-rot. This disease has ravaged our vineyards for more than forty years, and until this Department took up the matter three years ago no systematic attempt had been made to combat it or even discover its cause. It is now generally known that the disease is due to a microscopic parasitic plant, which, developing in and appropriating the juices of the grape, produces the effects with which every grape-grower is familiar. The life history of this organism has been carefully traced, and the light thus thrown upon its habits has enabled us to apply the proper remedies at the proper time.

In addition to the foregoing, the Section has published four circulars under the following titles:

No. 6, Treatment of Black-rot; No. 7, Grape Vine Diseases; No. 8, Experiments in the Treatment of Pear Leaf-blight and the Apple Powdery Mildew; No. 9, Root-rot of Cotton. The results set forth in Circular No. 8 are discussed more fully under Field Work. The edition of this circular was 5,000, but such was the demand for it that it was exhausted in something less than two weeks. The foregoing publications, all of which have been issued since January, 1889, aggregate 650 pages, 66 plates and 10 maps and 7 figures in the text.

It is gratifying to announce that there is an increasing demand for all of these publications. This has been especially noticeable since the adoption by you of special means for bringing more promptly and clearly before the general public the subjects under investigation.

The Section has in preparation four special bulletins, one of which is now about ready for the printer, and it is hoped that the rest will be ready for submittal within a year.

During the year the Section has received and answered something over two thousand five hundred letters, these for the most part relating to subjects requiring more or less investigation. It frequently happens that days or even weeks of painstaking research must be made before some of the questions propounded can be answered satisfactorily, so that the care of the correspondence alone consumes fully one-third of my own and my assistants' time. This work, too, is of a character that makes little or no showing before the general public, nevertheless we put forth every effort to encourage it, as we believe it is a most important means of disseminating useful knowledge.

The Section has now been fairly established three years, and the steady increase of the correspondence is shown by the fact that the first year the number of letters received was about five hundred, the second year one thousand five hundred, and this year, as already stated, something over two thousand five hundred.

II.—FIELD WORK.

The work of the Section is divided into two parts, namely, laboratory investigations and field experiments. The first, of course, must be done in order to intelligently undertake the second. Our general plan is to thoroughly investigate a subject in the laboratory, supplementing

it by such field investigations as the subjects in hand show to be necessary; then, when our knowledge of the particular disease is sufficient to warrant us in undertaking experiments in the way of combating it, a locality is selected where the malady is more or less prevalent, and a practical man is appointed to carry out such experiments in the way of treatment as we may suggest. When the disease is widespread, two or even three agents in different parts of the country are selected, in order that the trials may be made under different conditions of climate, soil, etc. Finally, if the results of such experiments indicate that a certain remedy has value, we give it to the public, together with such additional information bearing upon the subject as may be considered useful. We have found that our agents have been the means of disseminating much valuable information, and that wherever these men have treated their crops others in the same locality have not been slow to follow their example.

An instance bearing upon this point was met with last spring at Charlottesville, Va., where we have had an agent located for three years. Our agent's first attempt there at treating grape diseases was looked upon with indifference by the general run of vineyardists. The second year, however, quite a number were sufficiently interested in the matter to purchase apparatus and apply the remedies, and their results led others to do likewise. Last spring, matters had reached such a stage that the grape-growers clubbed together and purchased their chemicals by the car-load, and no less than fifteen improved knapsack spraying pumps were in use where two years before such a thing was almost unknown.

Our agents this year were located in New Jersey, Delaware, Maryland, Virginia, South Carolina, Mississippi, Missouri, Wisconsin, Michigan, and California, the principal diseases under treatment being black-rot, anthracnose, downy and powdery mildew of the grape; scab, rust, bitter-rot, and powdery mildew of the apple; leaf-blight of the pear and quince; potato-rot and blight; melon blight, strawberry leaf-blight,* the California grape disease, and peach yellows. In two cases, namely, Michigan and Wisconsin, we co-operated with the experiment stations; this arrangement proving highly satisfactory to all parties concerned.

A.—Treatment of Grape Diseases.

In nearly all of the grape-growing regions east of the Mississippi the season has been one of exceptional humidity, thus furnishing the most essential conditions for the development of fungous pests of all kinds. In some places rain fell so continuously and so copiously that the remedies were washed off before they became dry. Despite all this, most of the preparations heretofore used in treating these maladies have held their own, thus demonstrating beyond question their value at all times and under the most unfavorable conditions.

Experiments at Neosho, Mo.—As heretofore, Mr. Hermann Jaeger conducted the experiments at this place, having under treatment two vineyards a fourth of a mile apart and containing 7 and 10 acres respectively. These vineyards, consisting of something over twenty varieties, were treated first from April 26, to May 24, with the Bordeaux mixture, made by dissolving 2 pounds of sulphate of copper

*This disease seems to be more generally known among horticulturists as "rust," which is an exceedingly inappropriate term, as the fungus causing it is entirely distinct from the true rust parasites.

in 4 gallons of water, and ¾ of a pound of fresh lime in 2 gallons of water, mixing the two solutions when cool and then diluting to 22 gallons. A number of vines of each variety were left for control. The second general treatment was made from May 24, to 29, most of the vines being in full bloom at the time, but fertilization was in no way impaired. For the third spraying, which was made from June 3, to 7, the strength of the Bordeaux mixture was doubled. At this time mildew and black-rot were abundant on many of the untreated vines, the treated ones being generally healthy. The fourth and fifth treatments were begun on June 17, and July 1, respectively—a mixture of the same strength as the last being used. The sixth treatment was begun July 15, and as some of the early table varieties, such as Ives, Perkins, Martha, and Elvira were beginning to ripen, eau celeste, made according to the usual formula, was substituted for Bordeaux mixture. By adopting this plan the spotting of the fruit, which often follows the too free use of Bordeaux mixture just before ripening, was avoided. August 1, the seventh treatment was begun; this time the Bordeaux mixture, containing only 2 pounds of copper sulphate and ¾ of a pound of lime to 22 gallons of water, being used. At this date the vines were carefully inspected, with the following results, which, for convenience, have been arranged in tabular form:

Name of variety.	Fruit destroyed on treated vines.	Fruit destroyed on untreated vines.
	Per cent.	*Per cent.*
Norton	0	10
Uhland	2	80
Elvira	0	4
Clinton	1	65
Perkins	0	15
Ives	1	30
Martha	1	50
Concord	2	80
Telegraph	4	98
Delaware	0	40
Gœthe	4	95
Hermann	2	50
Elvira No. 100	0	5
Missouri Riesling	0	2
Aestivalis x Rupestr No. 70	0	10
Rupestris type	0	0
Average	1	40

From this date (August 1) to the time of picking there was no appreciable difference in the per cent. of sound and diseased berries excepting on the late untreated varieties. Thus a month later the untreated Nortons had lost from 15 to 20 per cent. of their fruit, but it is very probable that white-rot, which appeared about this time, was partially to blame for this. From the fact that the Nortons sprayed with Bordeaux mixture were almost wholly free from white-rot, Mr. Jaeger concludes that this remedy is certainly a preventive of the disease.

The copper compounds have proved such adequate remedies for mildew that it is hardly necessary to mention here the fact that despite the great amount of rain-fall this season their value was fully sustained.

The difference between the sprayed and unsprayed Elviras was most striking. The sprayed vines ripened a fine crop of grapes of such excellent quality and appearance that some buyers were led to believe they were getting California fruit, not being accustomed to

seeing native grapes of such size, purity, and sweetness. In concluding his report Mr. Jaeger says that by the 1st of September the mildew had not left a single leaf on his unsprayed Elviras, while those sprayed kept their foliage until a hard frost the 1st of October removed it. Any vine-grower will recognize the importance of this extra month's growth for the development of the wood and the consequent effect on the fruit the next year.

Experiments at Greenville, S. C.—The Piedmont belt, in which Greenville is located, was brought into prominent notice from about 1875 to 1885 on account of the immense crops of grapes it yielded. In 1885, however, black-rot appeared, and since that time there has been a steady falling off in the crop. According to Mr. A. M. Howell, our agent located there, the loss in infested vineyards in 1885 was about 10 per cent., increasing in 1886 to 25 per cent., and in 1887 to nearly 75 per cent. In 1888 every vineyard of any consequence was infested not only with black-rot but anthracnose and downy mildew as well. Previous to this year (1889) no systematic attempt had been made to check these maladies, and it was thought that if the copper compounds really possessed the value our experiments in other States had led us to believe they did, this would be an excellent opportunity to test the matter. Accordingly, Mr. Howell was directed to select two vineyards, endeavoring to have their soils, exposure, etc., as different as possible. The first vineyard of two acres and containing upwards of sixteen varieties was on Mr. Howell's own premises. The soil there is a strong red clay; the exposure a gentle slope to the southeast. The other vineyard, belonging to a lady near Greenville, is sixteen years old and occupies a hill-slope facing north. The soil in this case is a sandy loam underlaid with red clay. Neither of these vineyards had ever been treated and their loss in 1888 from black-rot, mildew, and anthracnose was complete to all intents and purposes.

The vineyard belonging to Mr. Howell was divided into four sections as shown in the accompanying diagram. The arrows indicate the most common course of the wind, the dotted lines mark the divisions between the sections, and the shaded lines (*a*, *b*, etc.) indicate vines left without treatment.

Section 1 consists of five hundred and fifty-eight vines, embracing the varieties Concord, Ives, Salem, Hartford, Brighton, Delaware, Clinton, Moore's Early, Jefferson, Pocklington, Gœthe, Eumelan, and Catawba.

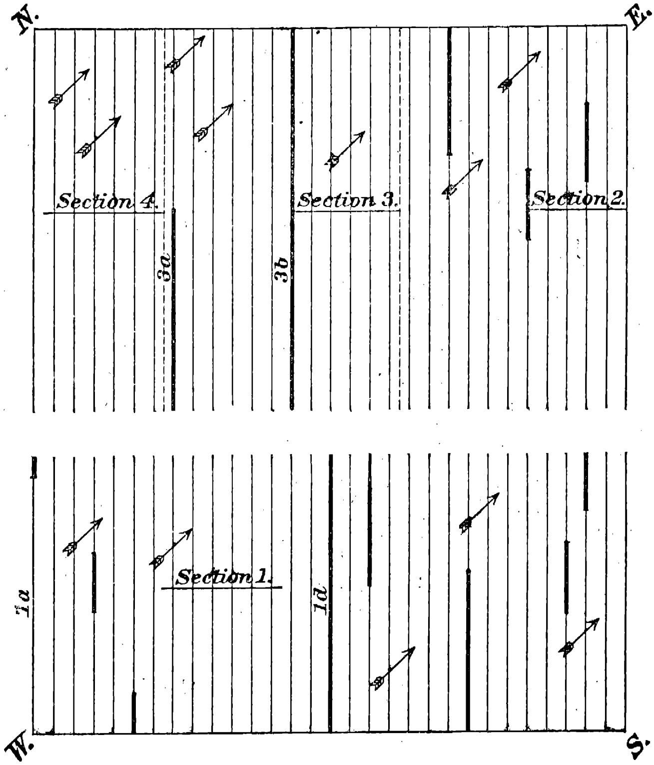
Section 2 contains two hundred and forty vines of practically the same varieties as No. 1.

Section 3 contains two hundred and fifty-four Concords.

Section 4 contains one hundred and fifty-four vines of Concord and Salem. This section was left untreated, for control.

Mr. Howell was instructed to use only the Bordeaux mixture containing 6 pounds of copper sulphate and 4 pounds of lime to 22 gallons of water. Following our instructions the first application was made to Section 1 with the Eureka sprayer April 23, and 24. May 10, the first signs of black-rot were observed on the leaves. Mr. Howell says that this discovery led him to make a close and careful inspection of the vineyard, but in none of the leaf-spots had the little black, spore-bearing conceptacles of the fungus made their appearance. Omitting the various details, the final results of this experiment are clearly shown in the table below.

Section.	Date of application.	Treated—Loss.	Untreated—Loss.
I	April 23, May 9, 30, June 17..	Estimated one-tenth of 1 per cent........	25 to 50 per cent.
II	May 9, 30, June 17............	Estimated one-tenth of 1 per cent........	50 per cent.
III	May 17, June 6, 17...........	Treated tardily and at inopportune times, too late, really after infection had taken place. Loss 15 to 18 per cent. except in experiments 3a and 3b, treated early with section 1. Loss on treated vines of row 3a, 10 per cent., and on treated row 3b, next to nothing, say 2 per cent.	75 to 80 per cent. These eleven vines the only ones left entirely without treatment in section 3.
IV	....	....	95 per cent.



In the second vineyard, already referred to, the results, were fully as conclusive as those set forth above. In one case two rows in the midst of an acre of vines were sprayed, all the rest being left without treatment. The sprayed rows ripened a perfect crop of fruit "without spot or blemish," while the loss on the untreated vines was fully 50 per cent.

There was very little damage to any of the vines from mildew and anthracnose; it was observed, however, that wherever the treatments were made these diseases were entirely absent.

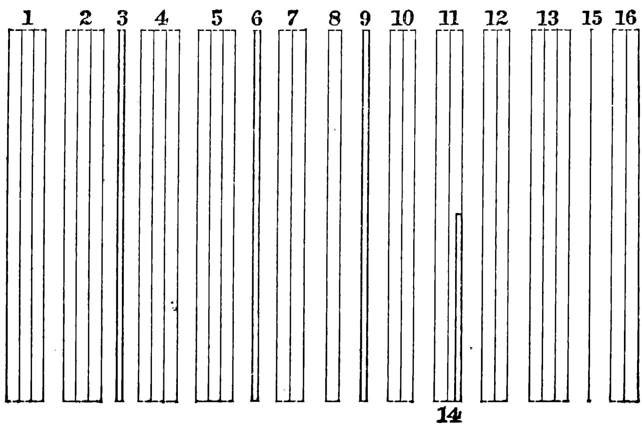
Concerning the cost of the treatment, Mr. Howell says, that for his vineyard of 1,206 vines the materials used were 100 pounds of sulphate of copper and one barrel of unslaked lime, costing $7.50 and $1.10 respectively. Counting the cost of labor and the wear of the

machine, the total expense of the treatment was about $12.50 or 1 cent per vine.

Mr. Howell's experiments have certainly shown what can be done by prompt and energetic work, and we believe that his labors will prove an object lesson by which many of the Piedmont grape-growers will profit.

Experiments at Eastham, Va.—Mr. A. L. Holladay, who conducted the experiments at this place, has lost a large amount of fruit of late years, chiefly from black-rot, anthracnose, and downy mildew. His vineyard being mostly Nortons it was thought best to confine the treatment to them, as this plan would bring out more clearly the value of the different formulas. The area under treatment comprised about $2\frac{1}{2}$ acres and the number of vines something over 1,400. The preparations used were Bordeaux mixture, four formulas; eau celeste, two formulas; solution of ammoniacal carbonate of copper, solution of sulphate of nickel, solution of corrosive sublimate, mixture of sulphate of iron and lime.

The vineyard was divided into sixteen sections, as shown in the diagram below; the preparations used for each section being as follows:



Section.	Preparation.	Formula.
1	Bordeaux mixture *a*	Copper 6 pounds, lime 4 pounds, water 22 gallons.
2	Eau celeste *a*	Copper 1 pound, aqua ammonia $1\frac{1}{4}$ pints, water 22 gallons.
3	Untreated	
4	Bordeaux mixture *b*	Copper 4 pounds, lime 2 pounds, water 22 gallons.
5	Eau celeste *b*	Copper 2 pounds, carbonate of soda 2 pounds, ammonia $1\frac{1}{4}$ pints, water 22 gallons.
6	Untreated	
7	Ammoniacal solution	Carbonate of copper 3 ounces, aqua ammonia 1 quart, water 22 gallons.
8	Bordeaux mixture *a*	See section 1.
9	Untreated	
10	Bordeaux mixture *b*	See section 4.
11	Bordeaux mixture *a*	See section 1.
12	Sulphate of nickel	Sulphate of nickel 3 ounces, water 10 gallons.
	Corrosive sublimate	Corrosive sublimate 1 ounce, water 24 gallons.
13	Bordeaux mixture *c*	Copper 2 pounds, lime 1 pound, water 22 gallons.
	Ammoniacal solution	See section 7.
14	Proof in section 11	
15	Sulphate of iron *a*	Iron sulphate 6 pounds, lime 4 pounds, water 22 gallons.
	Sulphate of iron *b*	Iron sulphate 8 pounds, lime 4 pounds, water 22 gallons.
16	Bordeaux mixture *d*	Copper 3 pounds, lime 1 pound, water 22 gallons.

To Section 8 the first application was made when the berries were just beginning to form. Sections 10 and 11 received an application of the simple solution of sulphate of copper before vegetation started. Section 13 was sprayed in March with a saturated solution of iron sulphate. By these experiments it was hoped if possible to demonstrate the following:

(1) The effect of spraying the vines before vegetation started with a saturated solution of sulphate of iron.

(2) The effect of spraying at the same time with a simple solution of sulphate of copper.

(3) The comparative values, as preventives of rot, of the preparations mentioned in the above table.

(4) The proper time for making the first application.

On October 1, the grapes were gathered and carefully weighed, the following being the results:

Section.	Date of application. May.	June.	July.	Aug.	Aug.	Preparation.	No. of vines treated.	Yield.	Average per vine.	Remarks.
								Lbs.	*Lbs.*	
1	18	7	23	3	16	Bordeaux mixture *a*	120	307¾	2.56	
2	18	7	23	3	16	Eau celeste *a*	122	393¼	3.22	
3	....	....	....	....	....	None	20	20	1.00	
4	18	7	23	3	16	Bordeaux mixture *b*	163	357¾	2.19	
5	18	7	23	3	16	Eau celeste *b*	99	236¾	2.39	
6	....	....	....	....	....	None	21	11¾	.56	
7	18	7	23	3	16	Ammoniacal solution	108	159	1.48	
8	....	6	23	3	16	Bordeaux mixture *a*	92	158¼	1.72	First treatment June 6.
9	....	....	....	....	....	None	17	17	1.00	Treated in March with a simple solution of copper sulphate.
10	18	7	23	3	16	Bordeaux mixture *b*	146	470	3.21	
11	18	7	23	3	16	Bordeaux mixture *a*	165	574	3.48	Treated same as above.
12	18	7	23	3	16	Sulphate of nickel	4	8¼	2.12	
13	18	7	23	3	16	Bordeaux mixture *c*	23	52	2.26	Badly pillaged by boys.
13	18	7	23	3	16	Ammoniacal solution	108	159	1.48	
14	....	....	....	....	....	Proof in section 11	10	19½	1.95	This was sprayed once in March with simple solution.
15	18	7	23	3	16	Solution sulphate of iron *a* and *b*.	15	26¾	1.78	
16	18	7	23	3	16	Bordeaux mixture *d*	114	336	2.94	

It will be seen from the above that the best results were obtained from the use of Bordeaux mixture *a* and *b* applied first before the flowers opened, and when the vines were treated in early spring with the simple solution of sulphate of copper. It is true that eau celeste *a* in Section 2 makes a good showing, but this preparation burned the foliage so badly that great caution must be exercised in applying it. For this reason it is a remedy that can be placed only in experienced hands.

The importance of early spraying is shown by comparing the other sections with No. 8, which received its first application two weeks later than the rest. Here the average yield per vine is only 1.72 pounds, while the same mixture applied two weeks earlier gives a yield of 3.48 pounds, a gain of 1¾ pounds. The yield of the sections treated with iron and lime and nickel solutions show that in comparison with Bordeaux mixture these preparations have little value.

The season was one of the worst ever known, incessant rains falling during the months of May, June, and July. Taking this fact

into consideration the showing in favor of the treatment is, to say the least, quite remarkable.

Experiments at Vineland, N. J.—An extensive series of experiments in the treatment of various fungous pests was planned for this station, but unfortunately the work on grape maladies was rendered almost wholly worthless by the invasion of rose bugs (*Macrodactylus subspinosus*) at about the time the experiments were fairly under way. On the 24th of May swarms of the bugs invaded the experiment vineyard and by the last of June there was no fruit left for black-rot or anything else to work on. Several points, however, which seem worthy of mention were brought out by the investigations carried on here, chief among which are the following:

First. With the view of determining what effect the removal of the bark and spraying the vines in winter would have on the development of rot the following season, about seventy-five vines were stripped in December of all their loose bark and then sprayed with a solution of sulphate of iron, 2 pounds of the latter to the gallon of water. An examination of these vines in the spring showed that many of them were dead to the ground, the treatment apparently having been too severe. The living vines were again sprayed on May 10, with a solution containing 12 pounds of iron sulphate, 8 pounds of lime, to 44 gallons of water. Additional applications of the same preparation were made June 3, and 23. The rose bugs did not invade this section; the fruit, however, was totally destroyed by black-rot, thus showing that the treatment produced no beneficial results.

Second. A similar section to the above was treated in the same way excepting that the bark was not removed. None of these vines were killed but the loss from black-rot was complete.

Third. In all cases where the copper remedies were used throughout the season the damage from mildew was comparatively insignificant, notwithstanding the fact that the season was one of the most favorable ever known for this disease.

Fourth. In no instance did the remedies produce the least effect on anthracnose; in many cases the fungus causing this malady was found apparently thriving under a thick coat of Bordeaux mixture.

B.—Treatment of the Diseases of the Apple, Pear, and Quince.

1. Apple Scab.

Of all the diseases which attack the apple this is without doubt the most wide-spread and destructive. It prevails more or less seriously wherever the apple is grown, the loss varying with the climate and season all the way from one-fourth to one-half the crop. Until the present season very little in the way of a systematic treatment for this malady had been undertaken. It is true experiments had been made by Professor Goff and others, but these were of such a nature that they only showed the importance and necessity of more extended work. Early in the spring of 1889 a plan, designed to throw some light on the treatment of scab, was drawn up, and Prof. E. S. Goff, of the Wisconsin Experiment Station, and Prof. L. R. Taft, of the Michigan Agricultural College, were engaged to do

* These papers will appear in full in a bulletin soon to be issued.

the work.* The reputation of both these gentlemen was a sufficient guaranty that the experiments would be conducted in a thoroughly careful and scientific manner.

In accordance with a plan previously agreed upon, Professor Goff conducted his experiments in the orchard of Mr. A. L. Hatch, situated 3¼ miles east of the village of Ithaca, Richland County, Wis.

The trees, twelve in number, selected for the experiment were 12 feet high, their branches being low and hanging so that much of the fruit was near the ground. They were of the Fameuse variety, which is particularly subject to the disease, and were planted in 1875. For convenience the trees were divided into six lots of two trees each, and were sprayed the first time May 18 with the following preparations:

Lot 1, trees one and two, sprayed with a solution of sulphide of potassium, one-half an ounce of the sulphide to the gallon of water.

Lot 2, trees three and four, sprayed with a solution of hyposulphite of soda in the proportion of 1 pound to 10 gallons of water.

Lot 3, trees five and six, sprayed with a solution of sulphur powder manufactured by E. Bean, Jacksonville, Fla., in the proportion of 1 pound to 10 gallons of water.

Lot 4, trees seven and eight, sprayed with ammoniacal solution of carbonate of copper in the proportion of one part of the saturated solution to ninety parts of cold water.*

Lot 5, trees nine and ten, sprayed with concentrated liquid of the sulphur compound manufactured by E. Bean, in the proportion of one part to one hundred and eighty of water.

Lot 6, trees eleven and twelve; check trees left unsprayed.

With the exception of lot 5, which was sprayed only three times, the ten trees received seven applications on the following dates:

First application, May 18; second, May 30; third, June 4; fourth, June 17; fifth, July 1; sixth, July 24; seventh, August 10.

On July 24, the treated trees were carefully examined and it was found that the hyposulphite of soda had scorched the foliage slightly and also that the ammoniacal solution of carbonate of copper had colored the epidermis of the fruit a light russet brown, injuring them slightly, but in appearance only. The leaves also were of a rather peculiar leaden tint and dried rapidly when picked from the tree, pointing to a direct injury to these organs. Later examination, however, showed that this suspicion was unfounded.

At this early date the scab was present upon both sprayed and unsprayed trees and no decision could be made as to the value of the different applications; it was not until September 24, when the crop was harvested, that a true comparison could be established. At this date six basketfuls of apples were taken from each tree, except the one sprayed with the liquid sulphur solution, from which only three were picked; care was taken to pick two basketfuls from the lower branches and two larger basketfuls from the topmost branches, passing around the tree to secure each one. The apples were then sorted into three grades and the following table made out from the results:

* For directions in preparing see page 408.

Tree No.	Sprayed with—	No. of fruits examined.	Free from scab.	Slightly scabby.*	Badly scabby.	Total No. for the two trees.	First quality.	Second quality.	Third quality.
			Per ct.	Per ct.	Per ct.		Per ct.	Per ct.	Per ct.
1	Potassium sulphide	647	40.96	44.20	14.84	1,388	30.04	48.55	21.41
2	......do	741	20.51	52.36	27.13				
3	Soda hyposulphite	743	44.83	44.54	10.63	1,545	43.24	42.78	13.98
4	......do	802	41.77	41.15	17.08				
5	Sulphur powder	748	23.53	60.83	15.64	1,403	32.72	54.31	12.97
6	......do	655	43.21	46.87	9.92				
7	Ammoniacal carbonate of copper	666	74.02	24.02	1.96	1,345	75.02	23.35	1.63
8	......do	679	75.99	22.68	1.33				
9	Liquid sulphur preparation	328	42.38	48.47	9.15	690	42.90	48.90	8.11
10	......do	362	43.37	49.45	7.18				
11	Check	689	21.48	56.75	21.77	1.564	23.34	53.89	22.71
12	......do	875	24.80	51.54	23.66				

*Showing a few scab spots, but not enough to distort the apples.

It will be seen by an examination of the table that the ammoniacal solution gave decidedly the best results, and that all of the preparations were more or less efficacious in preventing the scab.

In regard to the cost of the treatment it should be stated, before we give the actual figures, that experiments of this nature are always more expensive than where a large number of trees are treated, consequently due allowance must be made if the matter of spraying a large orchard is under consideration.

Professor Goff used for each application 3 gallons of the fluid for each lot of two trees, the time consumed being fifteen minutes for two men or seven minutes per tree. Taking these figures as a basis, the total cost of the various treatments was therefore approximated as follows:

	Cents.
Sulphide of potassium:	
10½ ounces potassium sulphide, at 45 cents per pound	30
3½ hours' work, at $1.25 per day	44
Total	74
Hyposulphite of soda:	
2$\frac{1}{10}$ pounds soda hyposulphite, at 7 cents	15
3½ hours' work, at $1.25 per day	44
Total	59
Ammoniacal carbonate of copper:	
3 ounces sulphate of copper, at 9 cents per pound	02
3 ounces carbonate of soda, at 5 cents per pound	01
1 quart concentrated ammonia, at 15 cents per pound	28
3½ hours' work, at $1.25 per day	44
Total	75
Sulphur powder, manufactured by E. Bean:	
2 pounds of sulphur powder, at 10 cents per pound	20
3½ hours' work, at $1.25 per day	44
Total	64

For the liquid solution of sulphur, manufactured by E. Bean, no estimate can be made, as its market value is unknown. To these

figures must be added, of course, the cost in labor of the preparation of each mixture, which is unfortunately left out of the calculation, but as this is the matter of only a very few minutes there would be no serious addition to the actual cost, which is already, as Mr. Hatch suggests, much too high for applications on a large scale.

It may be fairly concluded from the experiment that apple scab may be almost entirely prevented at slight cost by spraying the trees once in two weeks with the copper carbonate solution, prepared as described below.

The experiments conducted by Professor Taft were practically the same as those made by Professor Goff, the only difference being the variety of apple under treatment and the substitution by Professor Taft of modified eau celeste for one of the sulphur preparations.

Twelve Northern Spy trees growing within the space of half an acre were selected for the experiment. They were divided into six lots and, as in the case of Professor Goff, treated as follows:

Lot 1. Sulphide of potassium in the proportion of 5 ounces to 10 gallons of water.

Lot 2. Hyposulphite of soda in the proportion of 1 pound to 10 gallons of water.

Lot 3. Sulphur solution from E. Bean, Jacksonville, Fla., in the proportion of 1 pound to 10 gallons of water.

Lot 4. Copper carbonate and ammonia, prepared by mixing 3 ounces of copper carbonate with 1 quart of ammonia, and as soon as all action had ceased diluting to 22 gallons. Experience showed 28 gallons of water to give better results.

Lot 5. Modified eau celeste, prepared by dissolving in hot water, in separate vessels, 2 pounds of copper sulphate and 2½ pounds of carbonate of soda. These were mixed, and before using, 1½ pints of ammonia added, and the whole diluted to 22 gallons. Experience showed 32 gallons to give better results.

Lot 6. Check trees, unsprayed.

On May 24, when the apples were about the size of large peas, the first spraying was made with a little Climax pump and a long hose fastened to the end of a 10-foot pole. The second, third, and fourth applications, made in the same manner, upon the 6th, 12th, and 25th of June, completed the treatment for this month. The fifth and sixth applications were made on the 6th and 24th of July, and the seventh upon the 1st of August. All seven of these treatments, made under varying conditions of atmosphere noted at the time—in some cases in the morning, in others in the afternoon—cover, as will be seen, a period of ten weeks. In all cases care was taken to cover every leaf and fruit with a fine spray, about 3 gallons per tree being required for the purpose, and ten minutes time occupied in the operation. The only injurious effects discovered, seen after the fourth application, seem to have been a slight discoloration of the edges of the leaves on the trees sprayed with the hyposulphite, and a streaked or russet appearance of some fruits sprayed with the copper solutions. The former injury disappeared upon a reduction of the strength of the soda hyposulphite solution, and the latter seems to have, upon further growth of the apples, disappeared to some extent, but not entirely.

The following table shows the climatic conditions under which the treatments were made, and the appearance of the fruit during the experiment:

No. of application.	Date of application.	Time of application.	State of weather.	Temperature.	Appearance of fruit.	Condition of weather between sprayings.
				°		
1	May 24	10 to 12 a. m.	Cloudy..	68	Fruit the size of peas. No sign of scab.	
2	June 6	1 to 3 p. m..	Clear ...	80	No scab on either fruit or leaves. No injury from fungicides apparent.	The weather was warm and dry until May 29, but from that date until June 5, there were showers every day.
3	June 12	....do	...do	80	Scab has not manifested itself as yet.	Rain fell on night of the 6th, and on 7th and 8th and was followed by pleasant weather.
4	June 25	....do	Hazy ...	82	Scab abundant on fruit and leaves. Trees sprayed with hyposulphite have foliage slightly injured.	The past twelve days have been cool with considerable rain.
5	July 6	8 to 10 a. m.	Clear ...	78	At least half the unsprayed fruits show scab. Nos. 1, 2, 3, less injured. Nos. 4, 5, but few small spots. They are streaked with russet.	For two weeks the weather has been warm and pleasant, without rain.
6	July 24	1 to 3 p. m..	...do	77	Slight increase of scab on all trees. No change noticeable in the relative amount.	Rain fell on the 14th and 15th, but the remaining days have been pleasant.
7	Aug. 1	....do	Cloudy..	70	No new scab spots are forming; those already started are not spreading.	From this date until the fruit was picked the weather was as a rule pleasant and quite dry, with rather cool nights and occasional rains.

It will be seen that in the early part of the summer, after the first application, the weather was warmer and much more moist than in the latter part of the season, a state of affairs furnishing at least one condition extremely favorable to the growth of the little parasitic plant which causes the scab, and making it necessary to apply the fungicides more frequently, both on account of the washing off of the latter and the rapid growth of the fungus.

The trees were all examined October 1, to ascertain the exact nature of the difference, noticed frequently by visitors to the orchard, between the sprayed and unsprayed trees. The first lot—potassium sulphide solution—showed more highly-colored foliage than any of the other trees, and two-thirds of the fruits affected with the scab, but in small spots only. The leaves of the second lot—sodium hyposulphite—appeared to have suffered from the too strong solution used early in the season, and the fruits seemed more scabby than in the first lot, but not so badly affected as in the third. The latter was treated with the sulphur solution, and appeared to be only slightly less affected than the untreated trees. Lots 4 and 5, treated with copper carbonate and eau celeste, respectively, appeared to be in the best condition among the treated trees, the fruits in both cases (more so in 5 than in 4) being slightly marked, however, with russet from the June applications; while the sixth lot, left untreated, had nine-tenths of its fruit spotted with large and numerous diseased areas. This was also the case with the other trees in the orchard.

The picking was begun upon the 5th of October, and, for compari-

son, the apples were sorted into three grades: (1) Those free from scab; (2) those slightly injured, and (3) those badly affected. In the following table the value of the different fungicides can be only roughly compared by means of the total number of apples produced by each lot, and their total weight:

Treatment.	No.	Yield free from scab.		Slightly scabby.		Badly scabby.	
		No.	Weight.	No.	Weight.	No.	Weight.
			Pounds.		*Pounds.*		*Pounds.*
Potassium sulphide	1	997	220	2,022	410¼	7	1
	1a	947	221½	3,637	761½	8	1
Total	......	1,944	441½	5,659	1,171¾	15	2
Sodium hyposulphite	2	1,013	257	3,246	732¼	28	3½
	2a	702	162¾	2,238	486½	37	6
Total	......	1,715	419¾	5,484	1,218¾	65	9½
Sulphur solution	3	582	156½	2,772	662¼	39	7
	3a	428	121½	1,871	484½	26	3½
Total	......	1,010	278	4,643	1,146¾	65	10½
Copper carbonate and ammonia	4	1,540	449¾	1,272	325¼	7	2
	4a	2,749	657½	2,795	588	6	0
Total	......	4,289	1,107¼	4,067	913¼	13	2
Modified eau celeste	5	1,707	679¾	217	59¾	0	0
	5a	2,276	494¼	1,581	459¾	11	2
Total	......	3,983	1,174	1,798	519½	11	2
Unsprayed	6	155	41	1,416	385¼	31	7½
	6a	210	60	1,082	296½	20	6
Total	......	365	101	2,498	681¾	51	13½

Thus it is peculiar at least that while the lot treated with copper carbonate produced 8,369 apples with a total weight of 2,012.75 pounds, the lot of untreated only bore 2,914 apples with a total weight of 796.25 pounds. While this difference might occur between two sets of trees treated alike in the same orchard, from other causes, it is significant that it does not occur between other two sets in this series. It is only, however, when a comparison of percentages is made that the comparative values of the different fungicides can be ascertained.

A comparison of the average weight of scabby apples with those free from the disease shows an increase of nearly 10 per cent. in favor of the scab-free apples, *i. e.*, that an apple free from the trouble is 10 per cent. heavier than a diseased one; but this comparison can not be carried too far, as an attempt to show that an apple free from scab sprayed with copper carbonate is on the average heavier than one not sprayed fails to be supported by the facts.

The estimates of the cost of treatment have been very carefully made, but it must be remembered that the materials were purchased in small quantities and consequently at an advanced price of at least one-third over what they could be obtained for in quantities such as

would be required for large orchards. Below are given the prices paid for the chemicals:

		Cents.
Potassium sulphide	per pound..	40
Soda hyposulphite	do....	6
Copper carbonate	do....	60
Carbonate of soda	do....	5
Copper sulphate	do....	10
Sulphur powder	do....	10
Ammonia	per quart..	35

As the trees selected for the experiment were quite large, the estimate as to the quantity of solution needed will probably not fall below a fair average; and the cost of labor in spraying as calculated will not amount to more than from 1½ to 2 cents per tree. The addition of an arsenite* for the Codling moth to the first application is suggested by Professor Taft, and would accomplish two purposes, with no additional labor in spraying.

In the following table is a careful estimate of the actual cost for labor and chemicals of the different treatments; but, as already mentioned, it should be remembered that the cost of materials would be reduced at least one-third when bought in large quantities. The labor also, as every fruit-grower knows, is not directly in proportion to the number of trees treated, it taking a little less than ten times the labor to spray ten trees that it does to spray one.

Fungicide.	Cost per tree as used for one application.	Cost of five applications for average trees.
	Cents.	*Cents.*
Potassium sulphide	5¼	20
Sodium hyposulphite	3¼	12¼
Copper carbonate and ammonia	7	25
Modified eau celeste	8¼	30
Sulphur solution	4½	*22.5

*This figure assumes five applications to cost five times as much as one application, which the author's figure shows is not the case. The estimate was necessarily made up from comparison later.

In conclusion, Professor Taft decides:

(1) That the sulphur solution did not have a sufficiently marked effect to make its application profitable.

(2) Sodium hyposulphite, if used in the proportion of 1 pound to 12, or 15 gallons of water, does not injure the foliage and would be of sufficient benefit to repay the cost.

(3) Potassium sulphide gave slightly better results than the hyposulphite, but is more expensive and is consequently not economical.

(4) Copper carbonate and ammonia is one of the easiest of all the mixtures to prepare, and comparatively lasting in its effects. It is slightly cheaper than the next, but seems to have rather less effect, and on account of its injuries to the fruit will be improved by substituting 28 gallons of water for 22.

(5) Modified eau celeste gave the best results, and by its use a difference in the amount of scabby fruit of from 50 to 75 per cent. can be produced, showing that with varieties liable to scab, such as Fameuse and Northern Spy, it will often make all the difference between

*Since this was written it has been has been shown that an arsenite can not safely be used with the ammonical solution of carbonate of copper,

success and failure. Thirty-two gallons of water should be used where the formula calls for 22. The russet coloring produced by this and the copper carbonate may be considered a slight injury to the appearance of the fruit, but even this is a matter of opinion.

This series of experiments seems to show that with many varieties of apples in localities where scab prevails either of the copper mixtures will add 25 to 50 per cent. to the value of the crop at a cost of not more than 25 or 30 cents for an averaged-sized tree, and an investment in apparatus and chemicals for treatment would certainly prove most economical.

2. Bitter Rot of the Apple.

This disease is one which seems to be little understood by fruit-growers, notwithstanding the fact that it has long been recognized as a serious pest. It is pretty generally distributed over the entire country, its characteristics being quite constant and well marked. As a rule it does not occur until quite late in the season, that is to say, when the fruit has about reached its full size; small brown or blackish specks then appear on the surface of the apple, and as they enlarge the tissues beneath collapse and the skin sinks in but remains unbroken. In a very short time one of these spots will spread over the entire side of a fruit, of course rendering the latter worthless.

In certain places in Virginia, Kentucky, Missouri, and Arkansas our agents report this season a destruction of from 50 to 75 per cent. of the crop by this malady. It frequently happens that the disease will start after the fruit has been stored for the winter, and in such cases the destruction of the apples is complete.

Excepting the work of the Department, nothing so far as we know has been attempted in the way of combating this disease. Last year a few experiments were made under our direction in Arkansas, and the results seemed to indicate that with proper care a part of the crop could be saved.

This year an attempt was made to combat the disease by Mr. George G. Curtiss, an agent located at Brooke, Va. About the middle of August Mr. Curtiss was directed to spray four trees of different varieties with a solution of sulphide of potassium, one-half an ounce of the latter to the gallon of water. The varieties Abram, York Imperial, Fallawater, Fall Pippin, and Limbertwig were selected for the experiment, their condition with respect to rot at this time being about as follows:

First. Abram, one-half showing rot spots.

Second. York Imperial, Fall Pippin, and Limbertwig from 5 to 10 per cent. affected.

Third. Fallawater, 90 per cent. affected and many entirely rotten.

Three applications were made at intervals of ten days, it requiring about 9 gallons of liquid for each tree. The result on the Abram was very marked, the disease being arrested after the first application and no more rot specks appearing; the perfect apples ripened thoroughly. A tree of the same variety not sprayed dropped all of its fruit before the apples were fully ripe.

Practically the same results were obtained in case of the Pippin and Fallawater, while two trees of the latter, on each side of the sprayed one, dropped every apple.

The York Imperial ripened a good crop of fine fruit, while the Limbertwig, owing doubtless to its dense foliage and consequent imperfect spraying, did not show as good results.

On the 24th of August Mr. Curtiss sprayed one tree and a half of York Imperial and two trees of the Limbertwig with the ammoniacal carbonate of copper solution. The fruit on the half tree of York Imperial not sprayed nearly all rotted, while the treated tree and a half matured a good crop. In conclusion Mr. Curtiss says:

As to results with the two solutions I could see but little difference. I was unable to obtain the carbonate of copper at first, so that the sulphide of potassium had the advantage in time. For myself I prefer the ammoniacal copper solution. It is apparently more permanent in its effects and more pleasant to handle. The sulphide of potassium slakes very quickly on exposure to the air, and is quite volatile, emitting a strong sulphurous smell which is especially offensive to persons with sensitive olfactories. I experimented with stronger solutions of each, even doubling the strength of the sulphide of potassium without injury to foliage or fruit. The copper solution, however, will burn the foliage when made materially stronger than the formula.

To apply on a large scale I think the best plan would be to mount a cask that would hold the 22-gallon solution between two wheels, which can be done by attaching the two short arms of the axle-tree to plates which can be securely fastened to the barrel with screws. Two wheels of a buggy will answer well. This can be pushed as a common hand-cart from tree to tree. In this put a small force-pump with hose about 8 feet long with spraying-nozzle. Two men could operate this quite rapidly, one to direct the spray and the other to work the pump. In this manner I am confident two men could spray two hundred trees per day, and with the right kind of nozzle the cost per tree would fall below 2 cents each time, or say 6 cents for the season, as I think three applications of the copper solution sufficient.

3. Apple Rust.

Apple rust, which was fully described in my last annual report, was made the subject of an experiment by Col. A. W. Pearson, our agent, located at Vineland, N. J. The disease manifests itself in the form of small yellowish spots on the leaves and rarely on the fruit, these gradually spreading until the whole tree presents a decidedly sickly appearance. The fruit on such trees seldom matures, so that in regions where the malady prevails the loss is often considerable.

The fungus causing the malady is known to mycologists as *Rœstelia pirata*, and one of the most interesting things in connection with it is its peculiar alternation of fruit forms. One stage of the fungus occurs on the common red cedar, causing the jelly-like masses known as cedar balls. These balls are made up of innumerable spores, bodies analogous to seed, which escaping and falling upon the young apple leaves germinate and ultimately give rise to the rust-spots. On the other hand, it is seen under the microscope that the rust spots on the apple are made up of little cups which bear within their walls spores quite different from those of the cedar balls. It is supposed that these spores when they escape from the apple leaves and fall upon the small branches of red cedar germinate and give rise to the cedar balls, thus completing the life cycle. These cedar balls in all stages of development can be seen at any time after the middle of August, but, of course, they are not usually noticed until the jelly-like forms are emitted the following spring.

For the experiment at Vineland two trees were selected for the spraying which for the last three years had been badly affected with rust. Tree No. 1 was sprayed once before the leaves started* with a solution of sulphate of iron, 2 pounds of the iron to 1 gallon of water. Additional applications of a solution containing 6 pounds of

*From our present knowledge of the life-history of the fungus a spraying at this time would seem entirely unnecessary, there being none of the cedar-apple spores yet produced.

iron sulphate and 4 pounds of lime to 22 gallons of water were made every three weeks until the 22d of July. At this time the leaves were as badly infested as in any previous year, the treatment apparently producing not the least effect.

Tree No. 2 was sprayed before the leaves started with Bordeaux mixture, the applications being repeated every three weeks until July 22. The foliage remained fairly healthy, yet the benefit resulting was not a sufficient return for the labor expended.

There seems to be little doubt that in many cases the body or mycelium of this fungus lives from year to year in the tree, and if this is true then the application of a fungicide could hardly be expected to produce any perceptible effect. On the other hand, it may be that the treatment if continued would, by destroying the spores of the form on apple, diminish the number of cedar balls and thus, indirectly ultimately lessen the chances of infection by the product of these bodies.

4. Apple Powdery Mildew.

The disease known under this name occurs abundantly throughout all the region east of the Mississippi River, and while we have received but few complaints of its ravages elsewhere it is very probable that it would make its presence known if there were plants for it to attack. On the apple it is confined almost entirely to young trees in the nursery, seedlings being especially subject to its ravages. It shows itself on these plants just as soon as the leaves begin to unfold and seldom disappears until frost. The affected plants at first turn grayish white, and close examination will show that they appear to be dusted with a meal-like powder. As the disease progresses the affected parts, especially the leaves, become dry and brittle and in consequence are of very little use to the plant. As a result of all this the tree becomes utterly worthless for budding, and where this method of propagation is practiced there is nothing to do but to pull the plants out or let them go until the next year. The latter alternative is not always a desirable one, for the reason that the trees have to be budded high on account of an extra year's growth. Frequently, too, the disease is as bad the second year as the first, so that really there is nothing gained and a great deal lost by the process.

The fungus causing this malady is known to mycologists as *Podosphæra oxyacanthæ* DBy.* On the apple its growth is quite simple, consisting of a mycelium or vegetative system, which is for the most part external, and minute spores borne on branches sent up usually at right angles to the leaf or other affected part.

When dry the spores are readily blown about by the wind, and in this way, aided no doubt by insects, rain, or other agents, reach healthy plants, where under the proper conditions of moisture and heat they germinate and ultimately give rise to the same kind of fungus from which they originated. It in all probability passes the winter in the form we have described, its spores and mycelium having been often observed on the tips of apple seedlings in spring before the leaves appeared. Occasionally the true winter stage is met with on the apple, but as this has little practical importance a description of it is not necessary here.

This year we made a series of experiments in the treatment of this disease at the nurseries of Franklin Davis & Co., twenty miles north

* We have recently received from Mr. Swingle, of Kansas, an *Erysipheæ* infesting apple seedlings, which does not appear to be this species.

of Washington, the results of which have already appeared in Circular No. 8, issued by the Section in September last. The experiments were planned with the view of discovering if possible (1) a cheap, practical, and efficient remedy for the disease; (2) the proper time for applying the same; and (3) the best means of application.

Nearly 400,000 seedling trees and budded stocks were experimented upon, the results of which may be briefly summed up as follows:

(1) The disease can be effectually prevented by the application of the ammoniacal solution of carbonate of copper.*

(2) In the nursery the total cost of the treatment need not exceed 12 cents per 1,000 trees.

(3) The first application should be made when the leaves are about one-third grown, and should be followed by at least five others at intervals of ten or twelve days.

(4) The remedy is cheaply and effectually applied by means of any of the knapsack sprayers provided with the Eddy Chamber nozzle and Vermorel lance.

5. Pear Leaf-blight.

Like the apple powdery mildew, this disease is most destructive in the nursery. It, however, attacks the leaves and fruit on large trees, often seriously injuring both. The fungus causing it is known as *Entomosporium maculatum* Lév., and for a full account of its life history the Annual Report of the Department for 1888 should be consulted. Experiments in the treatment of the disease were made in the nurseries of Franklin Davis & Co., near Baltimore, and at Vineland, N. J. The same remedy, *i. e.*, the Bordeaux mixture containing 6 pounds of copper and 4 pounds of lime to 22 gallons of water, was used at both places, but in the former case seedlings were treated, while in the latter bearing trees were experimented upon. In the nursery the disease usually appears about the time the leaves are full grown, causing the latter to become spotted, turn brown, and then fall. It is not an uncommon thing to see entire blocks of seedlings completely defoliated by this disease as early as the 1st of July. Growth is of course stopped, and consequently the trees can not be budded. By the application of Bordeaux mixture it was hoped that the foliage might be protected from the fungus, and enabled to continue its growth throughout the summer, thereby making it possible to bud successfully.

The first application of the mixture was made on June 5, the second on June 15, followed by three others at intervals of ten days, 50,000 seedlings, averaging a foot to a foot and a half in height, receiving the treatment. The mixture was applied with the Japy pump and the Vermorel nozzle, each application requiring the labor of one man a day and a half. The total cost of the five applications was about 50 cents per 1,000 trees.

The treated trees held their foliage throughout the summer, and made a strong, vigorous growth. They were budded the last of July, fully 95 per cent. of the buds taking without difficulty. In the same block a few rows of untreated trees lost all their foliage before the 1st of July, and were not budded in consequence.

The results of the experiment at Vineland were even more striking than those above noted. Here two large Beurre Clarigeau trees, which for a number of years had been badly affected with the leaf-

---

* Formula on page 408.

blight fungus, were sprayed five times with Bordeaux mixture, while a third tree of the same variety growing twenty feet distant was left unsprayed. The first application of the remedy was made in March before the leaves started, and was followed by the others at intervals of three weeks throughout the summer. The figures in Plate II are from photographs made the last of August, and show more clearly than a description the results of the treatment.

Where there are a number of trees to be treated, the large force-pumps used in spraying for the Codling moth and other insects will doubtless be found the most economical. Machines of this kind are manufactured and sold by the Nixon Nozzle and Machine Company, of Dayton, Ohio; the Field Force-Pump Company, of Lockport, N. Y., and others.

6. Quince Diseases.

The quince trees at Vineland, N. J., are annually affected with a number of diseases, chief among which are twig blight (*Micrococcus*), orange rust (*Rœstelia aurantiaca*, Pk.), and leaf blight (*Entomosporium maculatum*, Lév.). Sixty trees were treated this year with a view of preventing these maladies.

Six trees were sprayed in April with a solution of iron sulphate (copperas), and the opening buds were considerably injured thereby. These trees, however, came into full leaf and bloom and did not show any of the peculiar fungi until about the middle of July. The foliage then began to show signs of leaf-blight, but applications of the Bordeaux mixture every three weeks appeared to check this. The rest of the trees (fifty in number) were treated with Bordeaux mixture, the first application being made May 13, and the others at intervals of fifteen days until July 22. There was much less leaf-blight on these trees than on several in the same orchard left for control, but as regards the other diseases the results were negative, for the reason that neither the treated or untreated trees were affected to any appreciable degree.

C.—Treatment of Blackberry Rust* and other Diseases at Ocean Springs, Miss.

Experiments were made by Mr. F. S. Earle, our agent located at the above place, in the treatment of blackberry rust. The plants treated were of the Early Harvest variety and the remedy used was the Bordeaux mixture containing 6 pounds of copper and 4 pounds of lime to 22 gallons of water. The plants were young at the time of the first application, March 29, being from 2 to 8 inches high. The second application was made on April 4; and an examination of the plants at this date showed that 8 per cent. were affected with rust, and in the untreated rows 9 per cent. were diseased. On June 6, only one diseased plant was found in the treated rows, while the untreated showed eleven. June 19, two rusted plants were found in the sprayed rows, while the checks showed seven. Soon after this the disease disappeared. Mr. Earle says that the result is certainly very promising, but it will require another season's work to fully demonstrate the value of the treatment. He also remarks that there is no doubt as to the value of the treatment for the leaf-spot disease (*Septoria rubi*, B. & C.). This malady appeared abundantly during the warm weather of early summer, but the treated rows were

***Cœoma nitens*, Schw.*

at all times remarkably free from it. Experiments were also made by Mr. Earle in the treatment of plum and peach leaf-rust (*Puccinia pruni-spinosæ*, Pers.); powdery mildew of the grape (*Uncinula ampelopsidis*, Pk.), and the strawberry leaf-blight (*Sphærella fragariæ*, Tul.), a full account of which will appear in a special bulletin.

D.—TREATMENT OF THE POTATO, TOMATO, AND MELON FOR BLIGHT AND ROT.

1. POTATO ROT.

It is not necessary to say anything here in regard to the immense losses resulting every year from the ravages of potato rot. Every one will admit that the disease is beyond question the most serious enemy of this valuable crop. For fifty years or more it has been talked of and written about and the number of suggestions made and plans set forth for combating it have been almost endless. Of course in undertaking to combat a disease of such a nature numerous precautions must necessarily be taken. The experiments made, however, were designed merely to test the value of fungicides applied during the growing season, as it is well known that this is the period when the disease is most active and destructive. The *rationale* of such treatment will be more clearly understood when something of the life history of the fungus causing the disease is known.

Briefly stated, the body of the fungus in the majority of cases lives from year to year in the tubers, and these diseased tubers are often used for seed and the plants from them are very likely to be affected, the fungus passing out of the tuber into the young stalks and finally appearing on the under surface of the leaves in the form of the whitish, downy mildew familiar to all. This whitish mildew is made up of innumerable spores and their supporting stalks, each of the former being capable of infecting a healthy plant. The spores being exceedingly small and light are easily wafted from plant to plant by currents of air, and in this way an entire field will soon become infected, the disease starting from a few perhaps widely separated points.

It is known that a very small quantity of sulphate of copper will prevent the spores from germinating and consequently from infecting healthy plants; and the treatment was made with this fact in mind, Bordeaux mixture containing 6 pounds of copper sulphate and 4 pounds of lime to 22 gallons of water being used for the experiment. The first application was made when the plants were a foot high, there being no sign of blight at the time; and the sprayings were repeated every two weeks until the 10th of September. The variety treated was the Peach-blow, and for convenience the field was divided into three plats of seventy-five hills each. On November 5, the potatoes were dug, the yield of each plat being as follows:

Plat.	Remedy.	Yield.
		Pounds.
1	Bordeaux mixture	346
2	No treatment	154
3	Bordeaux mixture	283

Diameter of largest tuber on treated plats 5 inches. Diameter of largest tuber from untreated plat 3 inches. The treated vines kept

green until killed by frost November 5, while the untreated were killed by the blight a month previously. Plat 3 grew alongside of a row of trees, which probably accounts for the falling off in its yield.

The results obtained in this case are certainly very promising and it is hoped that another year more extended experiments can be undertaken, from which further and more important deductions can be made. To those wishing to test the remedy we will say that it is of the utmost importance that the mixture be applied early. The fact that the treatment is entirely preventive must constantly be kept in mind as on this hinges the whole secret of success.

We have found the knapsack form of pump the most satisfactory for this work, as with it a man can easily and quickly reach all the green parts of the plant, covering them with a thin film of copper, thereby practically rendering infection from outside sources impossible.

2. Tomato Rot.

Experiments in the treatment of tomato-rot were made by Mr. Howell, of Greenville, S. C., three rows of thirty plants each being under treatment. The plants under treatment were divided into three sections running crosswise of the rows. Section 1 was treated with Bordeaux mixture on June 15, and July 2, and 15, respectively. Section 2 was left untreated. Section 3 was treated on the same dates as Section 1 with the ammoniacal solution of carbonate of copper. At the time of the first spraying the tomatoes were about three-fourths of an inch in diameter and already some of them had begun to rot.

The final results of the treatment are given below:

Section.	Treated with.	Loss from rot.
		Per cent.
1	Bordeaux mixture	4
2	No treatment	60
3	Ammoniacal solution	20

Mr. Howell says that late in the season it became very apparent that the fungus was greatly injuring the foliage. During September, fully a month before frost, the plants of the untreated section assumed a spent and dying appearance and very few ripe tomatoes were on them. The section treated with Bordeaux mixture remained bright and green until frost and ripened fine, large fruit.

3. Melon Diseases.

Melons of all kinds in certain parts of New Jersey, Virginia, and North Carolina are subject to a disease which has come to be generally known as "blight." Frequently this malady manifests itself by a sudden wilting of the vines, followed by a dark discoloration of the stems and finally death. At other times the edges of the leaves turn brown, roll inward, and dry up; this disease usually appears at times when excessive humidity is followed by hot sunshine and is frequently spoken of as "rust." Again, the leaves became spotted with greyish white, and later brownish discolorations, causing a marked falling off in the vigor of the vine. The cause of the first

disease is not known; the second is due to *Colletotrichium Lindemuthianum* (Sacc. & Mag.), Br. Cav., the same fungus which attacks the bean, producing the malady known as anthracnose; the third probably owes its origin to a number of things working together, chief among which is a fungus known as *Septoria*.

Attempts were made this year to combat these maladies by the use of Bordeaux mixture, but the applications, although applied every ten days throughout the growing season, did not materially lessen the number of diseased plants. We do not accept this experiment as conclusive, since before any decided results can be expected it will be necessary to know more of the diseases themselves.

E.—Strawberry Leaf-blight.*

It is known that this disease usually causes the greatest injury by attacking the new growth which appears directly after the fruit is harvested. At this period the old leaves contain innumerable spores, and it is these that infect the young leaves. To prevent this the practice of burning over the plants just after the fruit is gathered has been followed with success, the young plants usually starting up and growing thriftily after the treatment. The complete destruction of the old leaves is usually effected by first mowing the plants, allowing the foliage to dry for a day or two and then burning. This year an experiment was made by Colonel Pearson, with a view to determine the effect of spraying the foliage with a strong solution of sulphuric acid. Several rows of strawberry plants, badly infested with leaf-blight, were sprayed with a solution made by mixing one pint of sulphuric acid with six gallons of water, the application being made soon after the fruit was harvested. As a result of this spraying the old leaves were as effectually destroyed as if they had been burnt with fire, and two weeks later the plants had started up fresh and green.

On the 16th of September we visited Colonel Pearson's place, and the difference between the treated and untreated points was, at that time, quite striking. The sprayed rows were fresh and green, while adjoining unsprayed plants left for control were badly blighted.

Where one has a suitable spraying pump it would doubtless be economy to adopt this method of destroying the old plants rather than the plan of mowing and burning with fire.

III.—CONCLUSIONS CONCERNING THE PRACTICAL WORK OF THE SECTION.

From what has been said it will be seen that the results of the work of this Section are, in the main, highly encouraging. It is of course too early to form any definite opinion as regards the value of some of the work, but we believe enough is known to warrant a more extended series of experiments along the same line. It must be remembered that the work we are engaged in is entirely new; there is no beaten path of precedent to follow, consequently it is to be expected that failure will sometimes follow our efforts. Heretofore the work of this nature has been confined almost entirely to grape diseases, since this year we have broadened our field, increasing thereby, as we have good grounds for believing, the usefulness of

* *Sphærella fragariæ*, Tul.

our labors. It has been our constant endeavor to make the work as thoroughly practical as possible, for we fully appreciate the fact that practical results are what the farmer, gardener, and fruit-grower are after.

In some respects the plan of conducting the experiments has not been entirely satisfactory, for the reason that we have been forced to rely too much on agents remote from the Department. This of course is unavoidable with a part of the work, but whenever practicable the more important experiments should be under the direct supervision of those in charge of the laboratory. This can only be made possible by providing the Section with a few acres of ground in the vicinity of Washington, wherein the various crops under treatment can be grown and experimented on at pleasure. We have keenly felt the need of such a station and appreciate the efforts being made to secure suitable ground for the purpose.

Plans have been made for an extended series of experiments next season in the treatment of peach-rot and blight, a disease which ranks next to yellows in its destructiveness to the peach crop. We also propose to attempt something in the way of combating pear blight, a disease which has yet baffled every effort at control. The work on apple-scab and other apple and pear diseases will be extended, and a special endeavor will be made to discover a cheaper and more practical means of applying the remedies.

The results of the potato and tomato-rot experiments have encouraged us to give the copper remedies a thorough trial for these diseases, and special attention will be given to the comparative cost of the different preparations, the best time to apply them, and the number of applications necessary. The grape work will be continued, as there are yet many points in the treatment of black-rot and anthracnose which need further elucidation.

We have now under way some experiments in the treatment of the diseases of cereals, this work being chiefly confined to the smuts.

These subjects will constitute the main part of this branch of the Section's work for the coming year, but it is very likely that new diseases will present themselves, thereby necessitating additional laboratory and field labor.

IV.—LABORATORY INVESTIGATIONS.

During the year the special subjects under investigation in the laboratory have been the diseases of the grape vine, bitter-rot of the apple, sweet-potato rot, pear blight, peach yellows, and the diseases caused by the powdery mildews (*Erysipheæ*). Some important discoveries in connection with these maladies have been made, the details of which will be published in the special bulletins to which we have already referred.

Within the last eight months our facilities for work have been greatly increased by the addition of more room and improved apparatus. A bacteriological laboratory with all the modern improvements has been fitted up, thus enabling us to greatly extend our field of research. A small green-house has also been purchased and has proved very useful.

For the work we are engaged in a collection of fungi is absolutely necessary; realizing this, we have spared no effort to make the herbarium what it should be. Three years ago the number of speci-

mens in the collection did not exceed three thousand; now there are something over fourteen thousand named, labeled, and mounted on seven thousand herbarium sheets.

During the year a large number of economic fungi have been collected, one assistant spending a month in the field engaged in this work. As soon as we have the illustrations ready, it is our plan to distribute these among the agricultural colleges and experiment stations. Each specimen will be accompanied by drawings, notes on treatment, etc.

With the exception of one new assistant, Mr. D. G. Fairchild, the laboratory force practically remains the same, those now actively engaged in this work being Dr. E. F. Smith, Miss E. A. Southworth, Mr. M. B. Waite, and Mr. D. G. Fairchild.

V.—INVESTIGATION OF PEACH YELLOWS.

During the year the work on this disease has been prosecuted with vigor, Dr. Erwin F. Smith having devoted his entire time to the subject. In addition to Dr. Smith's work, Prof. T. J. Burrill, of Champaign, Ill., has devoted considerable attention to the disease, his investigations being chiefly of a bacteriological nature.

When Dr. Smith entered the field as special agent he was confronted by a dozen theories of causation, many of them extremely difficult either to establish or disprove, and was even met by statements that there was really no such thing as yellows. From the conflicting statements of Michigan and Eastern growers it seemed probable that several diseases were confounded under one name, a fact subsequently established.

First of all it was necessary to determine the symptoms of the disease, to find whether any set of symptoms recurred constantly enough to warrant a belief in the specific nature of the malady, and then to test the validity of each theory by direct observation. There is no longer any reasonable doubt as to the specific nature of the disease.

The work already done has settled this and has laid a sound basis for the further prosecution of the investigation. This work has consisted in large part of very laborious field examinations in Michigan, Maryland, and Delaware. Over two hundred and fifty orchards, embracing many thousand trees, have been critically inspected during three growing seasons, to learn as much as possible of the nature, symptoms, progress, and severity of the disease. A synopsis of the work of 1887 and 1888, together with an outline of the history of the disease and of its present distribution, is embodied in Bullètin No. 9.

The field work has enabled us to discard many theories and to point out the lines along which further inquiry is now likely to be fruitful. But some additional field studies are necessary, especially on the Delaware peninsula, in northern Georgia, in southwestern Michigan, and perhaps in other peach-growing regions.

Two main lines of inquiry are now under way: (1) The theory that the disease is due to some parasite; (2) the theory that it is a disease of imperfect nutrition resulting from soil exhaustion. Each line of inquiry will require at least two years of labor and perhaps three before anything like full, final, and conclusive results can be obtained.

The first line of inquiry includes both laboratory and field work

and contemplates a minute and exhaustive microscopic and bacteriological examination of all parts of the peach tree; it also includes inoculations, excisions, experimental cultures, and various other examinations and experiments. This work is begun, and the results already obtained show conclusively that the disease can be conveyed from tree to tree by budding. Some of these budded trees are still living and will be carefully examined bacteriologically and otherwise. The results of two sets of excision experiments are complete. One series of experiments with diseased pits has also been terminated and another is contemplated. About five hundred peach trees budded on plum stocks have been set in three diseased orchards to determine whether this practice offers any hope of immunity. Extensive underground examinations are also contemplated next summer to settle, if possible, the root-fungus and the root-aphis theories, although as a result of the inoculations both these theories now appear to be ruled out. Copious notes have been taken of all facts seeming to have any relation to the disease, and a large amount of material is on hand or within easy reach for laboratory use.

The second theory, *i. e.*, that the disease is due to soil exhaustion, we are inclined to discredit, as a result of extended observations, and especially in view of the results obtained by inoculation. Nevertheless a very painstaking and complete series of experiments with fertilizers which contain some or all of the ash constituents of the peach tree has been planned and is now under way on a large scale in Maryland and Delaware orchards. Ninety-seven experiments (in two series, curative and preventive) with guano, wood ashes, lime, bone phosphates, soda, and potash salts, etc., will go far toward settling the vexed question *pro* or *con*, especially as these experiments are with varying amounts of the fertilizers, separate and mixed, on trees of various ages in different locations and on different soils. About 40 acres, all told, are now under treatment, and an equal area is being held for comparison. These areas are in twelve orchards in badly affected districts, on soil varying from light sand to heavy clay. These experiments were planned by Doctor Smith and are under his personal care. Their successful prosecution has already involved a great amount of time and painstaking labor. The first treatments were given in the spring of 1889. Some interesting conclusions might be drawn even from the first season's work, but it is believed to be wiser to wait for further developments. Another treatment is contemplated for the spring of 1890 and the final results will not be accessible before the following autumn or the growing season of 1891. Along with these we have begun a third series of experiments designed to ascertain whether yellows can be induced in orchards by constant cropping with potatoes and similar strong-feeding plants. Our plan is to grow two crops a year for the next three years between the peach-tree rows, treating comparison strips meanwhile to strong doses of unleached hardwood ashes. Untreated strips and blocks of like character are reserved in all cases for comparison, and every precaution will be taken to avoid sources of error and to bring the experiments to a happy conclusion.

Professor Burrill began his investigations in the autumn of 1888, and on the 1st of July, 1889, made the following statement regarding the progress of the work:

I have earnestly endeavored to find a cause for the yellows of the peach tree during the time since last September, when commissioned by your Department for the purpose. During the months of May and June especially I have left no chance

known to me of discovery in this direction unimproved. But I am obliged to report at this time that I have not been able to demonstrate that any particular thing is the cause.

I have found in the tissues of the root and of the old and young stems of diseased trees an organism, classed with the bacteria, which is not known to occur elsewhere. This organism has been frequently obtained by method of cultures under circumstances which preclude the possibility of its coming from anything except the inner cells of the tree. I now have it growing in artificial media and it exhibits all the peculiarities of a pathogenic rather than a saprophytic microbe. It has peculiarities which serve to distinguish it from all others of its kind, and I am convinced it has never before been described by any one. I found it in every set of specimens examined known to be affected with this disease, and have thoroughly tried in the same manner to find it in healthy stock and failed.

Still, I can by no means assert that this organism has anything to do with the disease in question. My inoculations in healthy trees give no observable results, and I totally fail to find any evidence of parasitic action in the affected trees. It may be positively asserted that in the considerable numbers of specimens I have examined there is no fungus having a mycelium or usual organs of fructification. If the disease is really due to the microbe mentioned the malady differs widely from that of any heretofore described bacterial injury to living vegetation. The microbe must be sparsely but widely distributed through the still living tissues of the tree, in which it must very slowly develop without causing evident local disturbance. This latter especially is entirely at variance with known effects of parasitic organisms. But we know that the peach tree affected with this disease very gradually succumbs, lingering along several years without local injury of pronounced type. It may therefore be that both the apparent failure of my inoculations and the failure to discover local effects of parasitism in diseased trees are strictly in line with the progress of the disease by natural infection. At any rate I must express myself as completely in the dark in regard to the cause of the disease unless really due to the organism I have obtained. I have repeatedly found that after the tree tissues have otherwise suffered, as by partial drying after removal from the tree some days, or by death of the tree by borers, etc., the special microbes referred to in this communication can not be found. I have obtained it only in living tissues, fresh from the growing trees. In occasional instances it has been obtained in culture from every bit of inner bark used from a given limb, but commonly we have many failures to one successful result.

In regard to my methods of work, I am thoroughly positive that a thing which I regard as coming from the inner cells of a plant has been so derived. I am not deceived by external contaminations. Abundance of these latter have been met with, but in almost every case under conditions where reasonable explanation could be given for them. Doubtful exception is to be made to one organism, different from that heretofore spoken of. I have repeatedly found a second species which seemed to come only from the living cells. I am well aware that this weakens the probability of the first mentioned germ being the true cause of the disease, but while I have not found the second one elsewhere, I am by no means certain it may not be readily so obtained. It is a small *Bacillus* which produces unusually large and peculiarly hardy spores. These latter are not easily killed by heating in fluids. Quite possibly this is the key to their somewhat frequent appearance in my cultures. The first named microbe produces no spores, is easily destroyed by heat and by disinfectants. I have learned to recognize it almost positively in both liquid and solid cultures by the unaided eye. But in thousands of such cultures it has never appeared except as I have taken it from the diseased peach trees.

I do not call this a report. It is a statement of the main facts I now have relative to this mysterious disease. If a report is now called for I will furnish it, including the detailed statement of the methods pursued and a full description of the microbe.

Professor Burrill was directed to continue his investigations along the line indicated by the foregoing, it being your wish to settle the matter one way or the other.

VI.—THE CALIFORNIA VINE DISEASE.

For a number of years the grape vines of southern California have been dying in a mysterious manner. Hundreds of acres of flourishing vineyards have been swept away, entailing losses impossible to calculate. In 1887 Prof. F. L. Scribner, my predecessor, in company with Prof. P. Viala, of Montpellier, France, visited the in-

fected region, Professor Scribner acting under instructions from the Commissioner of Agriculture of this Department. Professors Scribner and Viala remained in the field but a short time and did not arrive at any definite conclusions as regards the cause of the malady.

Aside from a general correspondence with various parties in the State no further effort in the way of investigating the subject was made by the Department until early in March of the present year. Soon after assuming charge of the Department the matter was laid before you, and you immediately instructed me to make the necessary arrangements for sending a special agent to the infected region. Mr. Newton B. Pierce, of Michigan, was selected for the work, and early in May was appointed by you and immediately left for the field of labor. At my request Mr. Pierce has furnished a brief synopsis of the work to date, a copy of which we give below:

SANTA ANA, CAL., *December* 6, 1889.

SIR: The following brief review of work on the California vine disease is submitted in accordance with wishes expressed for such an outline, and is chiefly intended as indicating some of the lines of investigation pursued. To properly establish the special or general conclusions to whi h my work has thus far led me would necessitate the analysis and presentation of a mass of observations and notes incompatible with the extent and purpose of this account.

Most of the time since my arrival in California has been devoted to active field work, and the facts accumulated and observations made are invaluable as a foundation for the laboratory work and experiments which will naturally follow. Through personal field work, covering the greater portion of the worst infected district, we are also enabled to fairly judge of the merits of the various local opinions or of individual observations and views, and to be in a position to draw conclusions not to be arrived at with a more limited view of the field. I believe, however, that this position should be strengthened by a thorough canvass of the grape-growing districts of the northern portion of the State.

Very respectfully,

NEWTON B. PIERCE,
Special Agent.

B. T. GALLOWAY,
Chief of Section of Vegetable Pathology,
Department of Agriculture, Washington, D. C.

The disease now destroying the vineyards of southern California and working to some extent in the northern portions of the State began to attract the attention of the general public in 1885. The older vineyards located in the Santa Ana Valley, and particularly those of Anaheim, in what was then Los Angeles County, were the first to show marked signs of the disease in this region. At Anaheim the first requests were made for a special investigation into the nature and origin of the trouble, and were forwarded to associations or individuals of the State. Later, as the trouble began to seriously affect the great raisin industry of the valley, correspondence was opened with those in authority at the Department of Agriculture, at Washington.

Pursuant to directions from the Secretary of the Department of Agriculture, issued May 16, 1889, I proceeded to Santa Ana, Cal., to prosecute investigations into the nature of this disease, under instructions from you. On May 23, I arrived at Santa Ana and at once began the work.

After making the acquaintance of some of the leading grape-growers of the valley, it became my primary object to acquire familiarity with the effects of the disease on the vineyards as a whole, and more particularly the special effects on the vines attacked. To this end a large number of vineyards of the Santa Ana Valley received personal inspection. In reviewing this matter, I see that at least one hundred vineyards of the valley were inspected, in most cases with care, and these vineyards ranged in extent from garden patches to those comprising several hundred acres of vines. At the same time the owners of these vineyards, as well as those gentlemen formerly interested in grape culture but now having their vineyards removed, were visited, and their experience as a whole or any special observations or experiments which they had made were carefully recorded.

On working over the field here mentioned a general study was made of the foliage, body, and roots of the diseased vines. The study has been continued throughout the field work of the season, and has resulted in a thorough diagnosis of the effects of the disease, numerous descriptions in general and special cases being prepared and preserved. The material now in hand illustrative of the characters and effects of the disease is of considerable extent and value. It comprises, besides descriptive matter, a series of photographic plates of the effects of the disease upon the fruit, the vine, and the vineyard as a whole. Besides this, I have procured several excellent water-color plates representing the effects of the disease upon the leaves and canes of the vine—the use of colors being the only means of properly bringing out these characteristic features.

In gathering data relative to the introduction of the disease at various places it became evident that the trouble had spread in southern California from a common center. As we passed out from that center vines similarly located, of like age, and of the same variety showed signs of the disease in later and later years. Facts of this character, bearing directly on the contagious nature of the disease, at once showed the importance of procuring as complete records as possible of the dates of first appearance of the disease in each locality. With this object in view, the vicinity of Anaheim, where the Mission vines first died, was thoroughly canvassed and various facts and dates brought together sufficient for the construction of a map for that region. These have now been supplemented by like data from other portions of the State, and the material in hand at this time is sufficient for the draughting of a map of approximate accuracy for all the counties included in southern California, showing the spread of the disease and other facts of importance.

Much attention has been given to the probable origin of this trouble, but from facts already gathered I incline to the view that this matter must also be investigated in the northern portion of the State before any definite or satisfactory results may be looked for. I have, however, accumulated much material which may tend to throw some light on this branch of the subject.

It has been advanced by some who have studied this disease here that it is identical with that of Italy and adjoining regions known as *Mal nero*. Viewed from an anatomical and physiological stand-point there are many features of this disease reminding one of the Italian disease, and this is also true with the external appearance of the canes. On the other hand I have examined the foliage of five varieties of Italian vines from the diseased district and find no similarity between the two diseases so far as this material is concerned. Even were the identity of our disease with the Italian *Mal nero* thoroughly established, the benefits to be derived from such a recognition would be next to nothing, for up to this time the European authorities have been wholly unable to agree among themselves as to the nature of their disease, and no satisfactory remedy or preventive has yet been found. Owing to the similarity of these diseases I have thought it best to work up the literature on *Mal nero*, which is quite extensive. Translations of reviews of the various Italian papers published for many years back have been made, numbering some twenty to twenty-five papers, and many of the original articles and specimens of some of the Italian diseases have been procured, and more are to follow.

Certain other effects noticed in European vineyards, and spoken of as *Folletage* or *Apoplexie*, have been identified with our disease by certain persons of the State. This view might justly have been held when the disease first made its appearance, but since that time facts have developed which leave no good ground for supposing the trouble to be due to the direct action of the sun, as in the case of sunstroke. Owing to a remarkable connection existing between the temperature of the air and the virulence of the disease, however (as is also true in the case of *Oidium* on vines or of yellow fever or cholera with man), and the difficulty of determining the true nature of this relation, I have given more than ordinary attention to this feature of the subject. This has brought forth many facts of observation by others and by myself, and resulted in supplying me with what seems abundant evidence of the inefficient nature of heat when considered as a lone factor in the causation of this disease. In this connection, the effects of certain warm spells of winter, to the action of which the trouble has been ascribed, have received attention. For instance, vineyards set since these warm spells occurred and from cuttings brought from other portions of the State have taken the disease. But the various reasons for my conclusions respecting the non-causal action of heat can not well be presented short of the space obtainable in a special report.

Most of the non-parasitic agencies for the production of the disease, as their action has been presented by numerous adherents to such views both here and elsewhere, have been carefully considered.

The subject of pruning has received all the attention required. That of irrigation has had special and exhaustive attention. All conditions are noted on irrigated and

non-irrigated lands, and the evidence is abundantly sufficient to prove that there is no causal relation existing between irrigation and the disease. The subject of soil poverty has been fully considered, as well as the matters of artificial fertilization and alkaline soils. The various drainage problems which have a direct bearing on the effects of some of the well-known root fungi have been carefully reviewed during the field-work, and if a root fungus be at the bottom of the trouble it is certainly not working according to the habits ascribed by Europeans to *Dematophora* and *Agaricus*. This fact, however, is not evidence against the presence of root fungi. The bearing of elevation has also been considered, but up to the present time I have had no favorable opportunity to make observations along this line at elevations greater than two thousand feet. The matter of atmospheric humidity has likewise been partially covered. Much statistical information relative to the conditions of climate during the past and present decades, the effects of prevailing winds or those of unusual severity, has been accumulated, and when combined with the results of personal observation will, I believe, show the slight bearing these matters have on the subject in hand. The beneficial or detrimental action of other forms of Phanerogams about vineyards has been sufficiently studied. Under this head the effect of shade on diseased vines has been marked, and, as its bearing on the nature of the disease is important, it has had continuous investigation; at the same time being compared with observations made as to the temperature of the soil at certain depths beneath the surface.

Under the head of degenerated stock, due to long-continued propagation of vines from cuttings, I have been able to make several observations, but for the sake of bringing together a greater amount of material my attention to this subject will be continued. Yet I may say that up to date there is no good evidence that seedlings will exist longer in the face of this disease than vines long propagated from cuttings.

When considering the disease as due to parasitic or pathogenic organisms, three lines of investigation have been pursued, viz: Entomological, mycological, and bacteriological—the last as distinct from mycological work mainly in the method of treatment.

The work in these branches of the investigation is in no sense matured. It should be followed by much careful laboratory work, for which my time has thus far been insufficient, and by numerous careful experiments which are essential and important features in arriving at true results.

Work pursued in the field soon established the fact that Phylloxera did not cause the trouble, and although there are numerous insects and worms found upon the vine both above and below the surface of the ground, and which have been more or less studied, yet it seems evident that none of these bear any causal relation to the destruction of the vineyards. I might add that every order of insects is here represented upon the vine, and some of these forms are doing sufficient damage to well deserve the expenditure of the time required in making a careful study of them. I have given some time to the *Termitidæ*, which are doing much damage to the older vineyards, and will devote more time to certain *Acarina* and *Nematoda* found infesting the roots.

On the roots of the vine I have found *Vibrissea hypogæa*, but thus far only on varieties from the East. The gonidial stage of another fungus has been observed; also an extremely fine mycelium, clear, variably septate, branching as it passes *outward* through the cortical parenchyma to the epidermis. Much of this mycelium measures about 2 μ in diameter. The study of these forms is now in hand, as well as that of the various effects of the disease observable throughout the tissues of the root.

On the foliage and canes of the vine there are several saprophytic and some parasitic fungi observed; some of which are determined and others have to receive continued study.

Downy mildew, *Peronospora viticola*, has not been found by me in southern California. The same may be said for this region respecting black-rot, *Læstadia Bidwellii;* neither the *Phoma* of the berry nor the *Phyllosticta* of the leaf having been seen. No fruit affected by anthracnose, *Sphaceloma ampelinum*, has been observed.

Powdery mildew, *Uncinula ampelopsidis* or *Oidium Tuckeri*, which is a very common parasite throughout California, and which has occasioned much loss since its introduction a few years back, has been considered with much care and will continue to be the subject of attentive investigation. The indirect effects of this parasite, as well as those of Phylloxera, may easily be confounded with those seen at an early stage of the disease in question. In fact, any parasite whose action is to materially reduce the nutrition of the plant as a whole may produce effects analogous to those which may be termed the general or constitutional effects of the

present disease upon the foliage of the vine. Besides these general effects there are those of a special nature, however, which will not be so easily mistaken for those produced by other causes. In the present disease, especially well marked in the Muscat vines, we may usually see in the first stages several small yellow spots within the parenchyma of the leaf farthest from the main veins of the same. These spots are often very well defined in outline, more particularly when the leaf is held between the observer and the light. Often no indications of the effects of higher fungi or of insects can be detected externally or internally in these spots. The peculiar appearance and location of these spots led to a careful study of the same, which resulted in finding bacteria-like bodies (*Micrococci?*) in large numbers within the chlorophyllose cells of the spongy parenchyma immediately surrounding the spiral vessels supplying that region.

After a long series of observations, made on material from various portions of the diseased district, which in no case failed to disclose the diseased vines as swarming with these bodies in all portions where sap had a ready flow, I believed it proper to undertake a series of experiments to determine if these bodies, always present, bore any relation to the disease as a whole. I had little doubt that they were micro-organisms and gave to the local spotting of the leaves their characteristically sharp outline. Cultures from various parts of the vine were made in agar-agar and other media. Three sorts of bacteria were found with enough constancy to warrant further study, but I have not so far been able to determine whether any of these are the cause of the disease. Healthy vines were procured, set, and inoculated; but in due time I found both inoculated and control plants showing signs of disease. Owing to our inability, thus demonstrated, to make a fair test of the action of the germs in the infected district, these and analogous experiments—such as grafting, the testing of hardy stocks, etc.—have been inaugurated at Washington, outside infection being carefully guarded against. These experiments may demonstrate the non-pathogenic nature of these germs. In view of the observations mentioned, however, and the fact that several Italian students have for years claimed that an Italian disease of similar characteristics is caused by bacteria, it is proper the matter should be decided if possible.

For three or four years vine-growers have been trying to save their vineyards by treating them with the Bordeaux mixture applied both as a preventive and cure. Most thorough and persistent tests of this fungicide and stimulant have been made. Various proportions of the ingredients have been used, and applications have been made at nearly all seasons and under all conditions. The result has simply been to produce the action of a stimulant on the vines. After an application the vines send forth a new growth. Through this encouragement other and repeated applications have been made. In some vineyards the foliage has been especially treated, while in others, acting upon the theory that the seat of the disease is in the cane or body of the vine, the applications have been made to these parts. Often vines have been carried over by stimulation for a brief period of time. The ultimate result has been, however, that not one vine is saved by this treatment—and yet thousands of dollars have been expended by vine-growers in an effort to save their property. A powder recommended by individuals of the state who have been conducting experiments, and which it was claimed would master the trouble, has been extensively made and sold upon the market here in the infected district, and has been thoroughly tested both as preventive and cure. It was a part of my labor to collect records respecting the results obtained by those who have carefully applied this powder, and up to date I have not found a person who has saved a vine by its use.

Many experiments have been conducted by vine-growers who have studied the workings of this disease, and in all cases their efforts have been seconded by me to the best of my ability—many tests having been made with more or less favorable results. Several series of experiments have been conducted with bichloride of mercury, one of the best of germicides; but although for a time a stimulated and approximately healthy growth was obtained, this soon showed signs of disease and the vines ultimately went back as with the use of the Bordeaux mixture. I have records of a number of tests made with other substances, but the whole may be summed up in the plain statement that a preventive or remedy for this disease is not yet known.

Observations of value have been made relating to resistant stocks, and this feature of the work will be continued. Yet from what is known it is probable that Vinifera tops can not be maintained on native roots in this region in the face of the present virulence of the trouble. The variation in the hardiness of varieties is evident and many notes are in hand on the subject. The effects of grafting on stocks of perhaps twenty different varieties have been recorded. I have noted the effects upon the raisin when considered from a market stand-point, the loss in productiveness of vines, etc.

The financial losses caused by this disease in southern California are very grave. From the disease being first confined to a small section of Los Angeles County, I have now seen it well developed in Santa Barbara, Ventura, Los Angeles, San Bernardino, Orange, and San Diego Counties. I have also received typical specimens from several sections in northern California, but will know its distribution more thoroughly after having worked over that portion of the State.

Although the grape industry where the disease is doing its work has been and is receiving a heavy blow, and the interests involved are extensive, still I can not but feel that the check in production will be of comparatively short duration, as has been the case in Europe with Oidium, Anthracnose, and Peronospora. Further than this the investigations are being pushed as rapidly as time and careful work will permit, and I see no good reason for supposing that they will not result in a thorough understanding of the causes of the disease in question. This, like all other work of its class, requires time, but with the conquering of the vantage ground of a complete understanding of the trouble we may hopefully look forward to the mastering of the matters of prevention and cure.

Prof. W. A. Henry, Director of the Wisconsin Experiment Station, being in California during the latter part of the past summer, was directed by you among other things to call on Mr. Pierce and canvass the matter of the vine disease with him and report. In his report Professor Henry says:

Most fortunately Mr. Pierce made a thorough canvass of the vine districts of San Diego County, and I had the pleasure of meeting him at San Diego and accompanying him on his visits to El Cajon, Fall Brook, and Escondido. If Mr. Pierce's diagnosis of the dreaded Santa Ana vine disease is correct, we saw ample evidence that the plague hangs like a black cloud over the whole of southern California. Every vineyard visited (and they were many) gave evidence that the disease had already gained a foothold, though its coming has been so recent that not a single vine is yet entirely dead. At Deluz we found the wild grape also affected, though not seriously. The fact that the wild species, which grows in natural situations and has never come under the hand of man for cultivation or pruning, is attacked is significant and should not be lost sight of in any investigation. I had planned to visit Mr. Pierce at Santa Ana, but the day that I called he was away from home attending work at Tustin, as I afterwards learned. I did not then have the pleasure of seeing him at the point where he is stationed, but as we were together several days in San Diego County and canvassed the matter very thoroughly, I do not think I would have gained much additional information had I met him at the latter point.

How this disease could spread over so large an area of territory in a comparatively brief space of time is a great surprise to me, and when I remember the desolation it has wrought in Los Angeles and Orange Counties I do not wonder at the anxiety that is expressed by the vine-growers in the regions where it is just appearing, and the general discouragement that pervades all sections.

Before I speak more particularly of Mr. Pierce's work let me give a brief description of the raisin industry. Anywhere in California the vine thrives and gives at least fair fruitage. All of southern California produces very thrifty vines, usually without irrigation, and owing to the almost entire absence of rain-fall before October there is very little trouble in drying grapes a few miles back from the sea-coast. While capitalists have embarked in the raisin industry to some extent it is preeminently an occupation for the thrifty fruit-grower of limited means, and it is this class of people that are of the greatest importance to the country. There is nothing expensive about raisin-making; the cuttings cost little or nothing, and the vines grow on the hill-sides or valleys, and bear paying crops without irrigation. In three years from planting the cuttings considerable returns are received; from that time forward the crop increases until about the eighth year from planting, when they give their maximum yield. Cultivation consists simply in keeping the weeds removed, and there is no further labor except that of pruning. The fruit can be cared for in drying and packing by women and children, and is one of the best sorts of out-door work. The raisin of California has forced its way to a high position in the leading markets, and I fully believe that it will yet be shipped to other countries at a profit. Owing to the summer rains in Mexico and the Southwestern United States east of California, there will be no competition on this continent that amounts to anything, and certainly countries other than Spain would have found out by this time if there were areas within them suitable to the raisin. With Spain as the only competitor there is little to fear.

Again, I am interested in this production because it comes in competition with no other of its kind in the United States. As matters now stand we are suffering

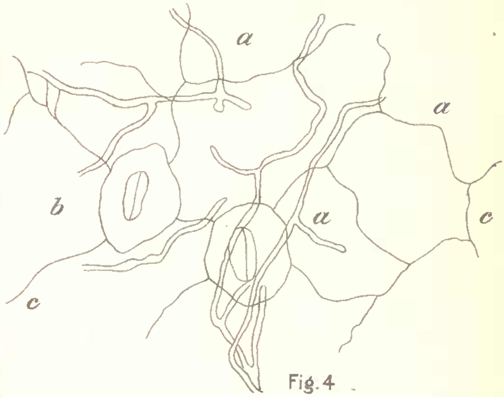


Fig. 4

Fig. 5

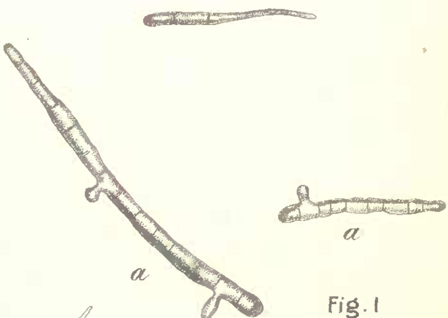


Fig. 1

Fig. 2

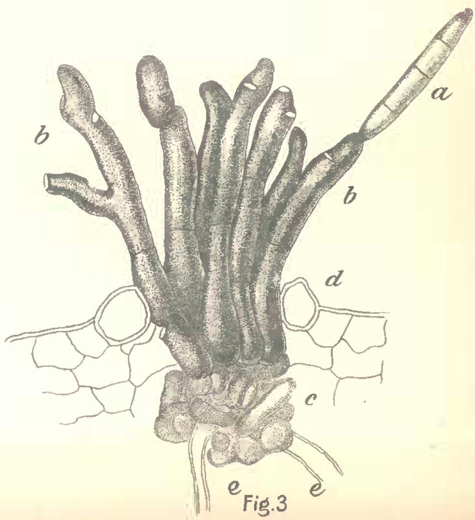
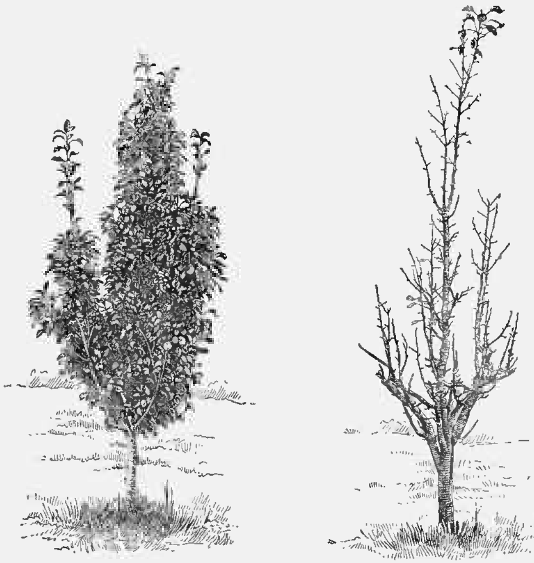


Fig. 3

Sackett & Wilhelms Litho Co. New York



TREATED. UNTREATED.

(Page 413.)

TREATMENT OF PEAR-LEAF BLIGHT.

(*Entomosporium maculatum* Lév.)

from an over-production of live-stock and grain, and need take no particular interest in searching for and developing new sections for these products, which would only add to the present over-supply. The raisin grower competes with no other, and gives us a product that is altogether wholesome and nutritious. This industry should receive careful fostering at the hands of the Government, and be shielded from everything that threatens to check its natural growth and drive it from the land. When Californians have learned to be content with small, reasonable profits and are willing to labor as industriously and continuously as Eastern farmers must do, if the vines produce as they have promised until the recent plague appeared, the raisin can be delivered in Eastern markets at prices that will make them an important article of consumption and nutrition. This industry has been growing as rapidly as it should for the best interests of all concerned, and though there are thousands of acres now planted, unless the trouble continues there will be 10 acres in a few years planted to vines where there is one now. Take the El Cajon Valley for example. From an elevated point on the rim of this valley we looked down upon 3,000 acres of bearing vines, most of which are giving their first crop this season. One single vineyard comprises 800 acres, and we were informed that the owner had expended $90,000 on it and this year he is to gather the first crop. At the time of our visit workmen were distributing 30,000 trays for driers among the vines. Within two or three years the area set to vines in this valley will probably be enlarged to 10,000 acres. At Escondido we visited a vineyard of 150 acres, which is old enough to give a very good crop this season. Several parties with small means have bought blocks of 10 and 20 acres each from this vineyard, having invested their worldly all in what they consider would bring them a fair income by careful attention and cultivation. As before noted, we found signs of the disease in every vineyard, though the attack is very recent. Wherever we went, as soon as the people learned the object of our visit they gathered about us and asked many questions, all parties showing deep interest and great anxiety. In all cases as soon as they were informed that the disease seemed to be present, the next question was if the agent had found a remedy. Naturally enough they care little for the name or history of the disease; all they want to know is how to cure it. I believe that no man could devote himself more enthusiastically to his work than Mr. Pierce has, and believe that he possesses a great deal of ability for this line of investigation. But it appears to me, especially when remedies and methods of preventing the disease are considered, that he needs support, and that, if possible, others should be sent to work in the same field.

VII.—A MIGNONETTE DISEASE.

(*Cercospora resedæ*, Fckl.)

[Plate I.]

By D. G. Fairchild.

For a number of years past the common Mignonette of the gardens has been known to suffer severely from a fungous disease, but owing to the comparatively small economic importance of the plant only slight attention has been paid to the matter.

EXTERNAL CHARACTERS.

The disease first appears either as minute pale spots with brownish or yellowish borders—little sunken areas in the succulent tissue of the leaf—or as reddish discolorations which spread over the leaf and finally develop into these pale spots or patches. The spots when young are simply dead portions, uniformly brown throughout; but as they become older and larger, little black specks appear in their centers, giving a somewhat granular cast. The disease spreads very rapidly over the leaves, the dead areas grow larger and more irregular in shape, the leaves commence to curl, wither, and hang limply against the stems, until in the course of ten or twelve days from the first appearance of the trouble the whole plant presents an appearance quite as if caught by a severe drought. If now it be examined

closely there will be evident large dark-gray or almost black portions scattered here and there over the shriveled leaves and often also upon the young seed-pods. These dark spots seem quite granular when viewed under a hand lens, which effect is caused by the numerous tufts or bunches of fruit-bearing threads of the little parasitic plant which causes the disease.

BOTANICAL CHARACTERS.

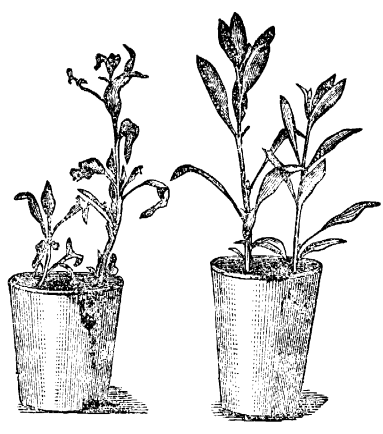
The vegetative part of the fungus consists of minute colorless threads (apparently without partitions or septa), which traverse the cells in every direction, sometimes growing into each other or anastomosing so as to form a more or less complete network under the surface of the leaf. This network may be perceived at once by a microscopic examination of the thin semi-transparent portion of the leaf, which is the immediate seat of the parasite (Fig. 4). When the mycelium has proceeded far enough in its existence to produce the reproductive bodies, or spores, the threads gradually collect in little mats or knots beneath the epidermis and send up, at first, only slight rounded protuberances towards the nearest breathing pore or stoma. These protuberances gradually elongate, pass out through the breathing pore of the leaf and become the hyphæ or fruit-bearing threads of this microscopic plant. These hyphæ (Fig. 3) when mature and viewed by transmitted light are of a delicate brown color, but when seen upon the surface of the leaf in tufts of ten or twenty appear almost black, giving the granular appearance so noticeable on completely dried portions. The hyphæ are from 50 to 70 μ long and 4 to 5 μ wide, and as shown in the figure have generally from one to two faint septa. A number of them are also branching, though the great mass are simple.

The spores or minute bodies which answer the purpose of seeds in this plant are borne on the tips of the threads, but owing to the fact that growth continues in the hypha and the spore remains attached, it sometimes appears as if the reproductive body was borne laterally. The spores are slender and colorless, clavate, or club-shaped bodies. They vary in size from 30 to 180 μ in length by 3 to 6 μ in diameter; they are often almost straight but sometimes are curved like a scythe and divided by from three to as many as twenty or twenty-five septa or transverse partitions. They germinate quite readily in water by sending out from several of their sections slender mycelial threads which, after about forty-five hours, attain a length almost equal to that of the spore itself (Fig. 2.). After a rain or period of moist weather the germinating spores may frequently be found upon the diseased portions of the leaf, showing that moist weather is undoubtedly if not a necessity at least of great aid to the growth of the fungus. These spores being exceedingly light and fragile may be carried by the wind from plant to plant or from one garden to another and alighting upon healthy leaves develop new diseased areas and destroy, partially or wholly, plants which before were perfectly healthy. Five or six days is abundant time for the freshly sown spores to cause very evident discolorations upon the leaves, and in a fortnight, unless some preventive is used, the whole plant presents a most dilapidated appearance. The cause of this rapid spread of the disease from one leaf to another in wet weather is found in the fact that almost immediately after the spore has gained a foothold in a healthy leaf it begins the process of producing

new spores in large quantities, and these, favored by the moisture, are permitted to germinate almost as soon as formed.

TREATMENT.

A simple experiment was conducted in the green-house of the Department to ascertain whether or not one of the common fungicides would check or prevent the disease. The plants, two varieties, White Pyramidal and Parson's White Tree, were planted July 10, in large pots, and transplanted August 10, to small ones with only two plants in a pot. These young plants were placed side by side upon the bench, and August 26, one-third of them was sprayed with an ammoniacal solution of carbonate of copper, one-third with the Bordeaux mixture, and the remainder left unsprayed. After sufficient time had elapsed to allow the fungicide to become dry, spores of the fungus seen to be in a germinating condition were sown on all leaves alike. In the course of five days the disease appeared upon all the plants to some extent, but much more violently upon those left unsprayed. September 5, they were sprayed as before and September 9, again, by which time the difference between the sprayed and the unsprayed had become very marked. Some weeks after the third spraying—which brought out the fact very plainly that the Bordeaux mixture was decidedly distasteful to the fungus and the ammoniacal solution only slightly so, also that the fungus was not confined in its attacks to either of the two varieties—average samples were taken from the unsprayed lot and that sprayed with Bordeaux mixture for representation in the cut below. Although the



conditions of this experiment were not wholly what might be present in the garden, the results obtained seem to point very strongly at least towards the efficacy of the Bordeaux mixture as a preventive remedy; especially so when it is remembered that the constant presence of the unsprayed diseased plants in contact often with those under treatment and the almost daily wetting from the green-house sprinkler, add two elements which in many cases would not be present to the same extent in out-door patches of Mignonette. It seems quite probable then that if the Mignonette-grower will spray his beds carefully while the plants are still young, with the

Bordeaux mixture—a very inexpensive mixture of copper sulphate and lime in the proportion of 4 pounds of lime to 6 pounds of copper, dissolved in 22 gallons of water—and repeat the operation whenever the yellow or reddish spots begin to appear upon the foliage, he will save his plants from this troublesome disease.

HISTORY.

This species was described and named by Fuckel in his Symbolæ Mycologica, 1869-'70, who put it in the genus *Cercospora*. Cooke, in Grevillea for June, 1875, describes the same species, giving it the name of *Virgosporium maculatum*, Cooke. Saccardo soon after pointed out the fact that Cooke's genus *Virgosporium* was identical with *Cercospora* of Fries, and that *V. maculatum* was the same as *Cercospora resedæ*, Fckl. The correction made by Saccardo was received by Cooke in Grevillea for December, 1875, consequently the name and description of Fuckel take precedence.

BIBLIOGRAPHY.

COOKE: Grevillea, 1874-'75, p. 182. *Virgosporium maculatum; ib,* 1875-'76, p. 69
ELLIS: Journal of Mycology, Vol. I, p. 21.
FUCKEL: Symbolæ Mycologicæ, 1869-'70, p. 353.
FRANK: Die Krankheiten der Pflanzen, Vol. II, p. 602.
SEYMOUR, A. B.: The American Florist, Sept., 1887, p. 38.
SORAUER: Pflanzenkrankheiten, Vol. II, p. 403.

PLATE I.

A MIGNONETTE DISEASE.—*Cercospora resedæ*, Fckl.

FIG. 1. Spores of fungus, *a* beginning to germinate.—D. G. F.
FIG. 2. Spores left in water forty-five hours, *a* germ tube.—D. G. F.
FIG. 3. Tuft of conidiophores showing, *a* spore, *b* hypha, *d* guard cell of epidermis, *c* stroma or mass of mycelium, *e* mycelial threads.—D. G. F.
FIG. 4. Mycelium beneath epidermis, *a* mycelial threads, *b* stomata or breathing pores, *c* walls of epidermal cells.—D. G. F.
FIG. 5. Diseased spray from infected Mignonette bed.—R. C.

PLATE II.

TREATMENT OF PEAR LEAF-BLIGHT.—*Entomosporium maculatum*, Lév.

REPORT OF THE POMOLOGIST.

SIR: I have the honor to submit my fourth annual report as pomologist of this Department. The past year's crop was very abundant except in the case of the apple, and the prices have generally been satisfactory to the fruit-growers. Each year widens the range of the growth and consumption of fruits. The raising by the farmers and small land-holders of fruit for home use is constantly on the increase.

Interest in the work of this division is steadily increasing. Inquiries regarding pomological matters have been received during the year from every State and Territory of the Union. More than ten thousand specimens of fruits have been received, sent either for identification or for study and comparison, and the labor required to properly examine these specimens, to make drawings or paintings of them as the case has required, to study their peculiarities, and to answer the inquiries and conduct all necessary correspondence has called into exercise the utmost resources of the division. The importance of diffusing knowledge as to the true names of fruits is such that I think it well to repeat the suggestions made in my report of last year to all who are interested in this work, that they apply to me for boxes and franks to enable them to send specimens here, free of postage, for identification or study, or as samples of the fruit products of different sections of our country. The extreme variations of climate in the United States effects wonderful changes in varieties of fruits, and to study these changes is not only intensely interesting to the scientific pomologist, but of great value to the practical fruit-grower, as he thus learns to know what variations are wrought by transplanting and their probable cause. The knowledge of the changes wrought in certain varieties often leads to correct conclusions as to other varieties, and a determination may thus be reached as to the propriety of their introduction or rejection without the expenditure of time and money in experiments.

PROCURING AND DISTRIBUTING SEEDS, PLANTS, AND SCIONS OF FRUITS.

Through the courtesy of the Department of State and of correspondents of this division, I have secured a few rare and valuable varieties of fruit from foreign countries; and several public-spirited citizens of our own country have donated seeds, plants, and scions of choice fruits of native origin, all of which have been distributed in those sections to which they seem to be best suited. They are as follows:

Sugar apple (*Anona squamosa*).—Seeds were received from the Philippine Islands and from southern Florida.

Cherimoya (*A. cherimoya*).—Received from Philippine Islands.

Cocos australis.—From southern Louisiana.

Egg fruit (*Lucuma rivicosa*).—Seeds obtained from Key West, Fla. This is a very rare and delicious tropical fruit.

Mammee apple (*Mammea Americana*).—A tropical tree bearing a large fruit. Seeds obtained from Key West, Fla.

Downy myrtle (*Myrtus tomentosus*).—This is a very beautiful shrub for the lawn, which bears a berry-like fruit of good quality. It is tender, except in the extreme south. Seeds obtained from southern Florida.

Japanese walnut (*Juglans seiboldi*).—Nuts obtained from Japan, and distributed in the central and southern States, where it is thought it may succeed.

Myrica rubra (*Myrica rubra*).—Seeds obtained from H. H. Berger & Co., San Francisco, Cal., who imported them from Japan; and I give their description of the tree and its fruit:

This evergreen fruit-bearing tree, indigenous to Japan, has only lately attracted the attention of botanists. It is a native of the southern part of Japan, attains a height of 40 to 50 feet, and a diameter of 2½ to 3 feet. The foliage, which is evergreen, resembles the magnolia, and is of a firm leathery texture. The fruit-blossom appears early in the spring, and the fruit ripens during the month of July. It resembles in shape a firm blackberry, an inch long by three-fourths of an inch in diameter. It contains a single seed stone of light weight. There are two varieties of this fruit, one a dark red, almost black, and the other a light rose, which is superior in flavor to the dark. The fruit is highly flavored, vinous and sweet, and answers all purposes our blackberry is put to.

It is delicious as a dessert fruit, makes a fine preserve, jelly, or jam. The juice extracted from it may be taken as a refreshing beverage in its fresh state, and after being allowed to ferment produces a fine wine; set with alcohol a brandy is gained from it equal to our famous blackberry brandy. The tree itself is highly ornamental, the bark is useful for dyeing a fawn color, and the timber is used in Japan for the most elegant cabinet-ware, having a finer mottled grain than the bird's-eye maple. The wood is light, tough, and very durable. The tree is perfectly hardy in all latitudes where the thermometer will not fall below 15 degrees above zero. It would succeed admirably throughout California, Texas, New Mexico, and all the Southern States of the Union.

The propagation of this useful tree is best carried on from seed to which it comes true, or by grafting scions from fruit-bearing trees on seedlings, which will thus come in bearing in a couple of years. The seed ought to be sown in leaf-mold and loamy soil, with bottom heat where obtainable. The same ought to be kept well shaded and mulched.

The natives of the provinces of Japan, where this tree forms small forests, say that the seed germinates best when having been eaten by birds it is passed through the excrements into soft leaf-mold in shady places, when it germinates in a few days; or if the seeds have by accident been thrown in a rubbish heap, soil and other vegetable matter, on being cleaned away, say after a month's time, seeds have been found well sprouted among the wastes.

The seed is light and ripens during July and August. Plants are not to be obtained as yet, the Japanese having never propagated the tree beyond the chance seedlings. There is no doubt that this tree would be a most valuable acquisition for California.

Myrica nagii.—This is another new species from Japan, seeds of which I imported and distributed in the Southern States.

Koshiu grape.—This is a variety of *Vitis vinifera*, which has been grown in Japan for nearly six hundred years, according to reports, and is the best grape they have in that country. Authentic accounts, as well as specimens of the fruit sent me from Japan, lead me to believe that the variety is not so good as many we now have of that species, and further introduction of the grapes of Japan will neither be necessary nor productive of good.

Granadilla (*Passiflora edulis*) is a species of Passion Flower from

the West Indies, which produces fruit abundantly and of good size and quality. In color it is externally a dark purple, and inside it is composed of a rather seedy tomato-like pulp, which has a very pleasant acid taste. It grows readily from seed, and although the vine dies down annually, the roots are perennial. It is only suitable to a very warm climate. Seeds obtained from Florida and sent to many of the Southern States and Territories.

Common guava (*Psidium guayava*).

Cattley guava (*P. cattleyanum*).—This is a small red variety. The species endures considerable frost.

Mexican guava, incorrectly called "Yellow Cattley Guava" (*P. lucidum*).

Kaki (*Dyospyrus kaki*).—Having received a great many choice specimens of this fruit from the Southern States, seeds were saved from such as I was able to identify as distinct varieties. These were sent south to be grown by careful experimenters, with a view to determining, by producing fruit from them, the extent of the probable variation of the seedlings of these varieties.

Cocoanut (*Cocos nucifera*).—Thirteen named varieties of the choicest kinds grown in the Philippine Islands were obtained through the consul at Manilla and distributed along the sea-coast in the extreme southern part of Florida, where they are already beginning to grow. The varieties are as follows: Grandes, Caputiformus, Rubiscens, Pequinitos, Maputi, Cayomanis, Bahan, Polac, Bosa, Boraves, Dajili, Dajila Patot, and Mamilaris.

Kelsey plum.—Grave doubts being entertained by many pomologists as to the hardiness of this plum in the Northern States, I secured scions of undoubted identity and placed them in several of the experiment stations for propagation and trial, wishing especially to determine just how far north it may be grown.

Summer Rose Apple.—Scions of this choice summer apple were obtained and distributed in both Northern and Southern States.

Mango (*Mangifera indica*).—Grafted trees of six of the choicest varieties known in the East Indies were obtained from Bombay and placed in the hands of experienced persons to propagate at Lake Worth, Fla. The varieties are as follows:

Alphonse.—This is said to be the best of all the mangoes known. In weight it averages about 8 ounces, and is of a greenish color enriched with crimson on the sunny side. It is slightly oblong, and lacks the prominent beak, which is a characteristic of many varieties. The tree is said to be a rather stunted and straggling grower. The leaves differ from many other kinds in having a bright-red midrib, which color is retained until they are mature and almost ready to drop. The variety is quite easily distinguished by this characteristic.

Pirie.—This fruit is about 8 ounces in weight, of a greenish color with a red cheek, and has a prominent beak at the end opposite the stem. In flavor it is exceedingly delicious. The tree is a good grower and takes a handsome shape.

Mulgoba.—This is a variety producing very large fruit, averaging about a pound. The skin is of greenish-yellow color and rarely blushed.

Banchore.—This variety bears fruit averaging 10 ounces, and is of superior quality. The tree is vigorous, upright in habit, and bears abundantly.

Banchore of Dhairey.—The average weight of this variety is about

8 ounces; in form it is oblong, without a beak, and is yellowish-green when ripe. The flesh is dark golden in color, very sweet, and has a peculiar sprightly flavor. The tree bears abundantly and is a good grower. It is said that this variety was considered so choice "by the ruler at Poona that he kept a guard of Arab soldiers over the original tree when in fruit to secure it for his own use."

Devarubria.—(No description obtainable.)

All the above varieties are entirely free from the fiber which is found in the flesh of common mangoes.

It will be noticed that a majority of the fruits distributed are suitable to the Southern States. This comes from two causes, namely: The fact that in the absence of any fund with which to purchase and distribute fruits I have been able to send out only such as were donated or sent to me in exchange, and such as are found in the colder parts of foreign countries have been more generally imported and distributed heretofore.

FRUITS ORDERED FROM FOREIGN COUNTRIES.

THE ASIATIC PERSIMMON.

Having been informed by members of the legations of Japan and Korea resident in Washington that there are growing in those countries varieties of the persimmon which endure climates where snow and ice abound, I have taken steps to procure, through the Department of State and other sources, seeds and grafted trees of the hardiest kinds, which, when received, will be distributed through the central States. This is one of the choicest fruits of eastern Asia, and especially is this true of Japan and Korea. It is my purpose to thoroughly investigate the subject and to introduce the best and hardiest varieties if we have not already obtained them. Many kinds introduced from these countries which are now growing here are elsewhere mentioned in this report.

THE FIG.

Fig culture is attaining great magnitude in this country, and it is especially important, in view of our large importations of dried figs, that we obtain the very best varieties known in the world especially for our fruit-growers in California, Arizona, New Mexico, and southwestern Texas. Many varieties have already been introduced, but it is the conviction of nearly all of the most intelligent horticulturists who are experimenting with this fruit that the variety or varieties from which the true fig of commerce known as the "Smyrna fig" is produced has not yet been obtained. I have therefore lately taken steps to obtain, through our consuls in several of the best fruit-growing sections of Turkey, information regarding this particular point and to secure cuttings of the variety or varieties from which the choicest dried-figs are made. Having learned that there are also very choice varieties of the fig growing in Peru, I have sent a request, through the Department of State, to our consul at Lima to make a thorough investigation and obtain and forward cuttings of the best varieties in that country.

ASIATIC PEACHES.

With the hope of obtaining a strain of peaches that will probably do well in this country, I have applied to our consuls abroad to obtain from Bokara in Turkestan several bushels of seeds of the choicest varieties grown there. It is barely possible that these may

produce a race of peaches that will be free from the dread disease known as "peach yellows," as to the cause of which authorities are disagreed but which is receiving the most careful attention of this Department.

THE GRAPE.

In the course of investigations regarding this fruit I have been informed that in Persia and Palestine there are varieties of the choicest quality of the species *Vitis vinifera*, which have not yet been introduced here. In the early part of this year I addressed a letter to our minister at Teheran and another to our consul at Jerusalem, asking that they investigate the matter and procure cuttings or rooted plants of the choicest kinds, naming and describing those which I especially desired to obtain. The following letter was received from Hon. E. Spencer Pratt, our United States minister at Teheran:

SIR: I have received through the Department of State your letter of the 20th of July last, inclosing a copy of a communication relative to a paper on vine culture in Persia, which Mr. Bernay, consul (general) of France at Tauris (Tabriz), had read before the French Acclimatization Society, and requesting that I furnish you with such information as I possessed or might be able to obtain concerning the particular vines mentioned in said paper, and that I forward you cuttings of the same if possible.

In this connection I beg to say that in a dispatch which I had the honor to address to the Secretary of State on the 28th ultimo, shortly before the receipt of your present favor, I called special attention to the superiority of the vines of the Persian table-lands, and suggested that your Department be recommended to consider the propriety of introducing the better varieties of these into the United States, where, under a more improved system of agriculture and with similar conditions of soil and climate, such as appear to exist in California, New Mexico, and other portions of the West, I was firmly of the opinion that the most excellent results could be obtained.

It is therefore with all the more gratification that I note the interest you are now taking in this matter and the desire you evince for attempting the very experiment I had proposed.

The Shaki Askari and Rich Baba or Galin Barmaghi are indeed most superior grapes and well deserve the praise that has been accorded them. They are to be found throughout the great pleateau as well as in the southern provinces, and in that of Azerbijan, of which Taris or Tabriz is the capital, and which the river Aras (Araxes) separates from the Russian Caucasus.

There are many and expensive vineyards about Casrine, and those about the neighborhood of Teheran are annually increasing, yet the capital derives its main supply of grapes both for table use and wine making from the district of Sharia, situated between the cities mentioned.

The Ispahan district possesses also a considerable acreage in vines, and so do Hamadan and Sharaz. All of these furnish their pro rata of grapes for food, for fermentation and distillation.

As in the past, however, so at this day, it is to the wines of Sharaz and Hamadan, and especially to the former, that the connoisseur awards the prize for excellence.

And I can not but think that there may be some foundation for the tradition that the vines which furnish the famous Spanish Sherries were originally derived from Sharaz stock, which after successive transplantations along the path of Arab conquests reached at last the peninsula.

Considering this high and well-merited reputation which these vines and their products enjoy, not only in Persia but throughout the Orient, they are entitled, I think, to special consideration. Concerning them I accordingly submit the following, which possesses the merit of coming from one who speaks from personal observation. There are two classes of vines grown at Shariz and in its district, viz, the irrigated and the unirrigated.

The irrigated vines are generally grown in the gardens and cultivated as follows: Ditches of about 2 feet in depth and three in width are dug in a zig-zag form, and the slips and cuttings are planted along their borders and at a distance of about 2 yards apart. The ditches are as a rule filled with water once a week.

These vines bear in about three years. Their fruit is used for the table and dried into raisins. The names of the best sorts are Askari, Sahrhi (which is pink in color), and Rich Baba.

The Askari and Sahrhi grapes are very delicate and ripen earliest. The Rich Baba can be kept until March.

There is also another kind which is named Sur Kush. These are thick-skinned and are generally used for making vinegar and sirup.

The unirrigated vines are those which are planted on the skirts of the high hills and entirely dependent for moisture on snow and rain. Their fruit is round, thick-skinned, and much sweeter than that of the irrigated sorts. It is used for making wine, sirup, and vinegar.

The best of the above varieties comes from the village called Khullar, situated 32 miles from Shiraz on a high hill, the slopes of which are covered with immense vine gardens.

Both the irrigated and the unirrigated vines are trimmed once a year, during the month of February, when the ground is also turned and manured if necessary.

I shall reserve for another occasion the further discussion of this subject, which seems to broaden as I enter upon it, and which, owing to the absence here of anything like agricultural or statistical bureaus for reference, will not admit, as you can well imagine, of being readily disposed of.

Already, however, I have begun to take the necessary steps for procuring from different sections cuttings or vines highest in repute throughout the empire, which, with such specific information in the premises as I am able to gather from the most reliable sources, will be furnished you as soon as possible.

The expense and trouble which the above will entail I shall be happy to assume in view of the object to be attained, and shall consider myself amply repaid if, through my efforts, our vine-growers shall be enabled to reproduce upon American soil the luscious fruits of Persia's vineyards.

I am, sir, your obedient servant,

E. SPENCER PRATT,
United States Minister.

THE DATE.

It may not be generally known that there are large areas in southern California, Arizona, New Mexico, and Texas where in all probability the date may be grown and cured for market. This fruit requires a semi-tropical climate. It will endure occasional frosts, but the air with periods of great heat during the growing season must be very dry. The soil should be rather rich and underlaid with plenty of water within reach of the roots. These conditions, I think, may be had in the regions above mentioned, which as a rule are very similar to those parts of Asia and Africa where the date is extensively grown for consumption and export. Water can be applied to the roots by irrigation, but of course it will be impossible to grow the date where this can not be done. It is now being grown in a small way all along our entire southern border, but it is only here and there that a few seedling trees may be seen. Being a diœceous plant, that is, the flowers of the two sexes being on separate trees, it is necessary that the two kinds be grown in proximity, in default of which the fruit will not come to perfection for lack of pollenation.

In date-growing countries it is found that one male in every twenty trees is sufficient to produce pollen for the others. Qualities and sizes of the several varieties differ greatly one from another, as is the case with other fruits, and we should therefore endeavor to secure rooted suckers only from the best fruit-bearing or pistillate trees. This can only be done by banking the earth about the base of old trees and watering it until roots have grown from the base of the suckers or side shoots, this being a slow process. I have during the past year communicated with our minister at Teheran, the consul-general at Cairo, in Egypt, and the consuls in Arabia and Algeria, giving them explicit instructions how to procure and forward rooted plants of the choicest varieties. It will necessarily take a great deal of time and entail some expense, but I trust the good to

be derived in the way of producing within our borders fruit which we are now obliged to import will well repay us. Even if we may not be successful in stopping foreign importations I feel confident that we will add materially to the list of choice fruits of home growth.

THE CITRON.

This fruit is closely allied to the orange and lemon. It has a very thick sweet rind, from which is prepared the article known by grocers and cooks as "preserved citron." This commodity ranges in price from 25 to 35 cents per pound, and is considered quite a necessary article by many of our people. Every pound now sold in our markets is brought from foreign countries, chiefly from the Mediterranean regions. In some parts of southern California and Florida the fruit is now successfully grown. A few experiments have been made in the way of preserving the fruit in this country, but all agree that the varieties they are cultivating are either inferior seedlings or such as are not entirely suitable for preserving purposes. I have therefore requested through the Department of State that our consuls at several of the ports in Italy from which the citron is exported obtain and forward budded trees of the varieties grown there, from which the finest commercial article is prepared.

NATIVE FRUITS.

WILD FRUITS INVESTIGATED.

Investigations have been continued with a view to discovering and developing the rich treasures which nature has scattered in the form of wild fruits, and often hidden in almost every nook and corner of our country.

In pursuance of this idea Prof. T. V. Munson, of Denison, Tex., was commissioned as a special agent during July, August, and September, and instructed to visit personally such sections as have been heretofore but little known, especially in the Western States and Territories. Mr. C. L. Hopkins, a clerk in this division, was detailed to accompany and assist him, and the salient points obtained will appear in the reports of this division as occasion may require.

THE CHESTNUT.

Nut culture is assuming more importance as an industry in this country than formerly; in fact until recently it has scarcely been attempted. Among the native nuts there are perhaps none of more importance than the chestnut. It grows naturally over a large part of the United States, beginning with Kentucky and Ohio, reaching northeast to the boundary and eastward to the Atlantic Ocean. The wild nut is exceedingly rich in flavor and very sweet. In these respects it is superior to the European or the Asiatic strains. Moreover our native chestnut seems to thrive much better than the foreign varieties, but in the size of nuts the latter have the advantage. A number of varieties of our American species, *Castanea vesca*, have been brought to notice, and are now propagated by grafting and budding, showing signs of a decided improvement as compared with the ordinary kinds found in the forests.

There are in Pennsylvania, Maryland, Virginia, Ohio, Kentucky,

Eastern Tennessee and the mountain regions of the Carolinas and northern Georgia, and all that part of our country lying northward of the States named (except in northern New York and a part of the New England States where the climate is not suitable) large tracts of lands now yielding small returns which might be profitable if planted to chestnuts. Many old worn-out fields which are practically worthless in their present condition might be thus turned to good account. The timber would be commercially valuable, but the nuts would bring much larger returns to the owner. Once started and cultivated for a few years, until they begin to shade the ground, the trees would require very little further attention except to thin them out. As an article of food the chestnut is very valuable, but at present the prices are very high. Even the common nuts from ungrafted trees would repay the use of the land, but it would be much better to plant only grafted trees of the choicer varieties.

In my report for 1887, directions were given for budding and grafting the nut trees, which is a rather difficult thing to do; but with proper care a reasonable degree of success may be attained.

Paragon.—Perhaps the most valuable variety yet introduced is the Paragon, which was brought into public notice by H. M. Engle & Son, of Marietta, Pa. It is possible that this variety may have some foreign stock in it, as the leaves differ slightly from those of our native species, but the trees seem to be very thrifty and have successfully withstood the winters of the last fourteen years in Pensylvania. Mr. Engle informs me that he "obtained it from a few scions received from an amateur horticulturist (now deceased) in Philadelphia, and never learned where the horticulturist got the stock," hence the origin is unknown. It has perhaps not been disseminated except through the firm now handling it. The tree bears abundantly and at an early age. The nuts are very large, averaging nearly an ounce in weight. The accompanying illustration (Plate 1) was made true to nature from specimens received this year from the Messrs. Engle.

Dupont.—A variety named Dupont has been received from Delaware and is a pure native seedling without doubt. The original tree near Dover, Del., is said to have borne from $30 to $40 worth of nuts annually for years past, but within the last year or two the rose-bug has partially destroyed its blooms. The nut is almost as large as the Paragon and fully equal to it in flavor.

THE PLUM.

Reference has been made to this fruit in all my annual reports, and the increasing value the native species are attaining warrants me in giving it special attention again. Native plums are found in almost every State and Territory of the Union, except it may be a small region in the extreme Northwest. The best varieties seem to be found in the region bounded by Minnesota and Wisconsin on the north and Texas and Arkansas on the south. A large number of varieties have been taken from their native habitats and brought into general notice. The Wild Goose, which is a native of Tennessee, is one of the choicest varieties and stands almost without a rival among the varieties of *Prunus chicasa*, which species includes nearly all the early ripening varieties.

Having again examined within the past year specimens of nearly all the leading varieties of our native plums, I feel justified in saying that among the best is the

Hawkeye.—I received specimens of this variety (Plate 2) from Mr. H. A. Terry, of Crescent City, Iowa, which measured $1\frac{2}{3}$ inches in diameter, and which were grown on an overloaded tree that ripened its fruit at the time of a severe drought. The flavor when fresh was equal to any of the wild plums I have ever tasted, and when cooked and critically tested, it was less acid than any others tried at the same time.

In color it is light red, and it is one of the handsomest wild plums I ever saw. It has been in the hands of experimenters since 1885, and thus far I have heard no complaint of its being tender. It is clearly evident from the fruit, wood, and leaves, that it belongs strictly to the species *P. Americana*, and I have no hesitation in recommending it to public attention and hope it may be thoroughly tested all over the country. It is possible that it may not endure the winters of some of the extreme Northern States, but it certainly thrives as far north as southern Minnesota and Massachusetts.

Mr. O. M. Lord, of Minnesota City, Minn., is one of the most extensive experimenters with hardy plums in this country, and has a large number of varieties, several of which are well worthy of trial. Among the newer kinds may be found *Rollingstone, Leudloff, Cheney, Gaylord, LeDuc*, and *Kopp*. All these belong to the species *P. Americana*, and will no doubt prove hardy in all the Northern States. It is not claimed that any of these varieties are equal to the European kinds, either in size or quality, but they are much hardier in character of tree and especially valuable as they are able in a great measure to withstand the attacks of the curculio.

Farmers and fruit-growers will act wisely in giving our native species a fair trial; for it is certain that if they do they will be abundantly supplied with fruit except it be under very unfavorable conditions.

THE CURRANT.

Among the wild fruits of recent introduction which are likely to prove of special value is the wild currant of our western plains and mountain valleys (*Ribes aureum*). A variety known as

Crandall—Was originated by Mr. R. W. Crandall, of Newton, Kans., from seed sown by him, which was produced by a plant of the wild currant, which had been removed to his garden from its natural habitat in southwestern Kansas. For many years past I have had opportunities to observe on many farms in Kansas and other Western States, wild varieties of this species, which had been transplanted into the gardens of settlers on the prairies, as well as growing in its native state along the streams and ravines of the States and Territories lying just east of the Rocky Mountains; and although many of the varieties were of good size and quality and bore abundantly, yet I have never seen any of them that equaled the Crandall. Branches of the plant that I have seen have been invariably loaded with fruit, and in my estimation too heavily loaded; many of the berries were one-half inch in diameter, and some even larger, and intensely black. I have eaten the fruit both in its cooked and uncooked state, and although in my opinion it is not equal in quality to some of our best varieties of the cultivated currant, it is far better than any of the black currants of Europe, having no strong odor or unpleasant taste. It is well adapted for sauces, pies, jellies, and other preparations usually made of fruit. The plant grows to a height of 4 feet or more and is well suited to the changeable climatic conditions of Kansas, Iowa, and Nebraska, and I think of the region even farther north, as I never heard of its

having been winter-killed, though varieties of this species are to be found growing wild in many of the Northwestern States and Territories. No insect enemies have been found to defoliate it, and in the Eastern States, where the ravages of the Currant Worm are disastrous to the common currant and gooseberry, it has never been found to attack the Crandall. A correct illustration made from a specimen received from Mr. Frank Ford, of Ravenna, Ohio, is found in Plate 3 of this report.

THE APPLE.

Among the many new and little-known varieties of this fruit which have been received at this office during the past year may be named several which give promise of valuable qualities.

Garfield.—The origin of this variety is unknown, but probably it was first grown in central or northern Illinois; and the name Garfield was first applied to it by Mr. J. V. Cotta, of Nursery, Ill., who propagated it extensively and brought it prominently before the public. Its chief points of excellence are hardiness of tree, combined with good quality and appearance of fruit, and it is a variety worthy of a more extended trial in the Northwest, where apple-culture is carried on in many cases with indifferent success. In the letter accompanying specimens of the fruit from which the colored illustration (Plate 4) was made, Mr. Cotta says:

> How well this variety is adapted to this section of the country is evinced by the fact that trees twenty-five to thirty years old are still in prime condition notwithstanding the severe winters of 1882–'85, which destroyed the greater part of our orchard trees.

Size, medium to large; shape, nearly round, slightly flattened, regular; surface smooth, brilliantly colored, with scarlet and crimson streaks and splashes over a yellow ground; dots numerous, small and gray; basin rather deep, abrupt, regular; eye closed; cavity deep, narrow, slightly waved, russet; stem medium; core wide, usually open, meeting the eye; seeds plump and numerous; flesh yellowish white, rather coarse grained, firm; flavor subacid; quality good; season November to January in northern Illinois.

Windsor.—This is another claimant for favor in the Northwest, having originated in Wisconsin. Specimens were received from Mr. J. C. Plumb, of Milton, in that State, who recommends it as one of the hardiest varieties he has in cultivation. The cut (Plate 5) is from a specimen grown by him. Professor Budd, of Iowa, says of it: "It stands best of any apple I have from Wisconsin." It appears to be a variety that will keep all winter when grown in that region. The tree is said to be handsome in appearance, very prolific, and an early bearer. Although not of large size it is of fairly good color and quite well flavored. It is worthy of trial by the farmers and fruit-growers of the Northwest.

Size, small to medium; shape, flat, conical, slightly angular in form and resembling the Red Canada; surface rather smooth; color greenish yellow, suffused with dull and indistinct red splashes, rarely striped; dots gray, numerous, large, surrounded near the base with russet; basin rather deep, narrow, abrupt, regular; eye small and closed; cavity wide, sloping, russet; stem medium to long, slender; core small, closed, clasping the eye; seeds small, elongated, pointed, rather light colored; flesh firm, fine grained, juicy, very pale yellow; flavor subacid, pleasant; quality very good; season, December to spring in Wisconsin.

Lacon.—This is also a candidate for favor in the North. Specimens were received from Mr. E. R. McKinney, of Lacon, Ill., this year, and the name Lacon was given it by myself. The original tree, which stood near the town whose name the fruit bears, is dead. Mr. McKinney says of it:

It makes a round compact head, wood short jointed, in all respects resembling at a little distance the Whitney No. 20 Crab. The tree from which I send you specimens, the Whitney No. 20 Crab, Red Astrachan, Romanstem, and Fameuse are all the sorts I have left in an orchard of nearly one hundred varieties. It is the healthiest of the lot, showing no signs of ill health, decay, or disease. In my opinion, on account of good bearing qualities, hardiness, size, and quality of fruit, notwithstanding its bad color it will be a good sort to introduce.

I concur in his opinion. The illustration on Plate 6, Fig. 1, was made from an average specimen received from Mr. McKinney.

Size, medium to large; shape, irregular, flattened, unequal; surface, smooth, yellow, and green, slight bronzy blush, a few russety splashes; dots, numerous, irregular, and russety; basin, deep, somewhat elongated; irregular and wrinkled; eye generally open, and sepals reflexed; cavity closed, narrow, acute, irregular, rarely russety; stem short, stout; core medium, open; seeds abundant; flesh yellow, firm, fine-grained, juicy; flavor mild, subacid, pleasant; quality good; season from October to January in northern Illinois.

Peffer.—A variety originated by Mr. George P. Peffer, of Pewaukee, Wis., from seed of Pewaukee apple, and named in his honor. (See Plate 6, Fig. 2.) It is thought to be better than the parent variety in some respects, and I bespeak for it a fair trial in the colder States. Size, medium to large; shape, diameters nearly equal, angular, irregular, slightly lop-sided; surface, polished, yellow with abundant splashes and flecks of bright red and scarlet, handsome; dots, numerous, brown or gray; basin, deep, abrupt, irregular or ribbed; eye, open, large, with reflexed sepals; cavity, medium, sloping, nearly regular, very slightly russeted; stem, short, thick, fleshy; core, open, small, meeting the deep eye cavity; seeds, many, large, plump; flesh, white, tender, fine grained, jucy; flavor, subacid; quality, fair to good; season, early winter in Wisconsin.

Bloomless and coreless apple (so called).—For several years past the rural papers have mentioned a variety said to be bloomless, coreless, and seedless, and after several trials I have been able to secure specimens from Mr. G. W. Robinette, of Flag Pond, Va., on whose farm the variety grows. (See Plate 7.) Its origin is a matter of considerable doubt, as varieties of similar description have been mentioned for many years and even centuries past. The tree is not bloomless, of course, as it would not produce fruit, but the flowers have no petals. The essential organs are, however, very well developed, and the pistils especially so. The fruit is small, dull red, mixed with yellowish green color, and only fair in quality. Several specimens received from Mr. Robinette in October of this year were carefully examined; each one was well supplied with seeds. Not only was there a core, but the core was unusually well developed, there being a secondary and even a tertiary core with a few seeds in each, extending towards the calyx and causing an opening there nearly one-half inch in width and about the same in depth. This variety is not valuable as a fruit, but as a botanical curiosity it might be of some interest to those engaged in the study of vegetable physiology. I mention it that the reader may not be induced to plant trees with the expectation of having choice fruit.

THE PEAR.

Philopena.—Within the past year there have been brought to my notice a few varieties of this fruit which are well worthy of notice. Of this number is the Philopena, a seedling variety originated by Reuben Ragan, that venerated pioneer pomologist of Indiana. He supposed it to have been grown from seed of the Seckel. The old tree is now about fifty years old and more than a foot in diameter, and so far has been free from disease, bearing large crops of fruit regularly. Specimens were sent me this year by Prof. W. H. Ragan, of Greencastle, Ind., the son of the originator. The illustration (Plate 7) was made from one of these.

Size, medium, 3½ by 2½ inches in diameter; shape, rather long, irregular, unequal; surface, rather smooth, bronzy olive, with a dull mottled blush on the sunny side; stem, short and stout; basin, shallow; calyx, small, closed; core, small, compact, connected by tough fiber to the stem; seeds numerous, rather small, and plump; flesh, firm, fine-grained, but becoming quite tender when ripe; quality, good; season, October to November in central Indiana.

GRAPE SIRUP.

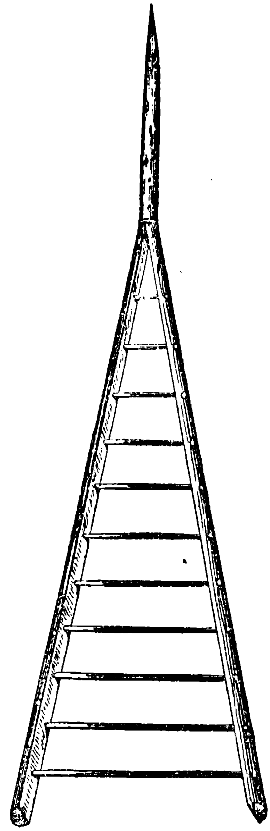
A new industry has just sprung up in California, which gives promise of being a profitable one to the grape-grower and very acceptable to the consumer of the product.

A sirup is made by evaporating the freshly expressed juice of the grape until it becomes about the consistency of molasses. In view of the fact that in California there are hundreds of thousands of acres planted to the varieties of *Vitis vinifera*, which are very rich in sugar, and that the price of wine into which they have heretofore been largely made is exceedingly low, it would seem that the manufacture of grape sirup is a good way to utilize the crop. I have been informed that this sirup can be produced at a cost not exceeding 50 cents per gallon, and if this be true I see no reason why it may not become a staple article of food as the means of production are practically without limit. Samples have been received from Snaveley & Baker of Woodland, Cal. These were thoroughly tested, and persons who are competent judges conceded that in quality it was quite equal to maple sirup. The flavor of the sirup depends somewhat upon the variety of the fruit from which it is made, but all the sirups have the peculiar delicate taste which reminds one of the best raisins. As a table sirup and for culinary purposes it seems, after trial, to be very satisfactory.

A FRUIT LADDER.

There is scarcely a farmer who does not occasionally need a ladder in gathering his fruit; and I take pleasure in submitting a drawing and description of the best one I have ever seen. Take a pole of any desired length, but not of large diameter, sharpen it at the top to a slim point, and several feet from the top put a flat iron band about it, or in case a band is not at hand it may be securely wrapped with wire to keep it from splitting. But the band should not be thick or with sharp edges else it may cut or chafe the bark of the tree. If the grain is straight it may be split with wedges from the butt to

this band, or it may be split with a rip-saw. Now spread it at the bottom to several feet in width, and if the ladder is to be quite tall this should be 5 or 6 feet or even more. Nail a brace temporarily across the butt ends to hold them apart, and bore holes at proper distances and at proper angles; or if the spread is not too great they may be bored before the pole is split. Rounds of tough, strong material may now be inserted, beginning at the top, first removing the brace.



Such a ladder can be thrust upward into a tree and placed in a fork or against a branch without danger of falling or being unsteady, and it has the additional advantage of being very light at the top and easy to handle. If desired, a third leg or brace can be added by hingeing it to the top round through a hole, thus making a step-ladder.

FRUIT-GROWING IN FLORIDA.

During a part of the months of February and March of the present year, I made an official visit to Florida for the purpose of becoming acquainted from actual observation with the condition of fruit culture there, and in order better to under stand the peculiar conditions with which the fruit-grower of that State has to deal. The citrus fruits, and especially the orange, which is the mainstay of the Florida fruit-growers, were somewhat past the flush of their season of ripening, but in every section visited opportunity yet remained to observe the ripe fruit upon the trees. The limited time at my command did not admit of a visit to the west coast, but the conditions in the central part of the State and of the east coast were thoroughly investigated.

The orange-growing section is bounded on the north by a line running east and west passing not far from Jacksonville, which is near the northern part of the State, and on the south by one running in a northeasterly direction from Charlotte Harbor, on the Gulf coast, to the Atlantic. South of the latter either the culture of the orange has been very little attempted or the climate is unsuited to it. The region between these lines contains sufficient land suitable to orange culture to produce a supply that will fully meet the demands of the entire United States for years to come. The product of California and Louisiana is not to be overlooked, but if it were necessary to secure the entire supply of oranges for the Northern markets from Florida (which is not the case) there appears to me no good reason why it might not be done.

The orange crop of Florida last year amounted to nearly 2,000,000 boxes, and observation leads me to believe that the trees now planted will produce within the next ten years 10,000,000 boxes annually, as

the orange tree is long lived and a continuous bearer under proper culture. Some of the oldest trees now growing in Florida will still be in full bearing ten years hence. It is not my purpose to speak with special favor of any particular part of the orange-growing section, as beyond doubt many places which I did not visit are equally as good as those visited. I endeavored to examine fruits of all kinds, as far as the season would permit, growing on all kinds of land, from the highest to the lowest and from the richest to the poorest. Some have thought good oranges can not be grown in the flat sandy pine land, but many orchards which I visited, and of which I carefully tested the fruit, gave convincing evidence to the contrary, and I believe that with proper fertilization and cultivation of the soil abundant crops may be grown on such lands. The great lack of Florida is rich land, but where rich soil is wanting good sense may be exercised with satisfactory results. Very rich and extensive phosphate beds have recently been discovered in western Florida, and this may solve the problem of commercial manures for the State. Toward the western part of the State there lies a broad, slightly elevated, ridge, running generally in a southeasterly direction, which in great part is covered by a growth of hard-wood timber, consisting chiefly of oak, several species of elm, hickory, magnolia, and red bay. The soil is of a much firmer nature than that of the pine lands, and is composed in part of clay; rocks protrude from the surface in some portions of these higher lands. Here may be seen some of the best orange orchards in the State, and I think it is universally admitted that such lands, where frosts are not likely to injure the crops, are the best suited to orange culture, and in fact to that of all citrus fruits. Such lands are usually called "high hummock," in contradistinction to the "low hummock," which, in addition to a similar growth of hard wood, bear also the cabbage palmetto, and lie near the level of the numerous lakes. It is in the hummocks that the wild orange groves are found, and never in the pine lands. These wild groves are seedlings from old plantations established by Spaniards and other foreigners who first followed the aboriginal inhabitants of Florida.

None of the citrus fruits are thought to be indigenous to the American continent, though a claim to the contrary has recently been made in behalf of Mexico.

On the east coast of Florida, running parallel with the ocean and separated from it by a narrow strip of land, are bodies of water, generally a little salt, reaching almost the entire length of the State. They are connected with the ocean by shallow inlets, and vary in width from one-half mile to several miles. They are narrow shallow sounds, but are commonly spoken of as "rivers." Such are Indian, Hillsborough, Halifax, and New Rivers, and such is Lake Worth. Along these bodies of water, and reaching but a short distance from them, are some of the finest and most productive orange lands in the State.

TROPICAL FRUITS.

As commonly understood, tropical fruits are such as will not endure frost without injury; and even in Florida the places where they will grow successfully are comparatively limited in extent. The influence of the water upon the cold-air waves which sweep over the country is well known and easily understood by practical fruit-growers. As in Florida the waves usually pass in an easterly or

southeasterly direction, the region south or southeast of the lakes is freest from attacks of frost. One location found in my travels along the southeastern shores of Lake Apopka was of this character, and although a frost had fallen over nearly all the State not long before I was there, the banana and pineapple plants and mango trees of this region showed no signs of having been touched; and there are many such protected nooks in other parts of the State. South of Charlotte Harbor, as I have been credibly informed, the tender plants and trees have for some years past suffered little or no damage by frost. On the east coast, beginning at the north end of Merritt's Island, which is a little south of the twenty-ninth parallel, the successful cultivation of the pineapple, banana, mango, sapodilla, and other tender trees begins; and having traveled the entire length of Indian River to Jupiter Inlet and beyond, I can state from personal observation that the culture of these fruits is carried on quite successfully, though in a rather small way. This is especially true of the long strip of land lying between Indian River and the Atlantic Ocean, where I saw many acres devoted to the culture of the pineapple. At Eden, which is on the mainland on the west side of Indian River, there are some of the most extensive pineapple plantations in the State.

A desire to examine the Lake Worth region led me to pass south of Jupiter Inlet, 8 miles from which point lies Lake Worth. This body of water is about 30 miles long and averages about a mile in width, and upon its borders I found

THE COCOANUT (*Cocos nucifera*)

growing luxuriantly and bearing abundantly. Nothing that I have ever seen in the form of trees or plants excels in graceful beauty the waving leaves of this tropical palm. The oldest of the trees were raised from nuts planted by Mr. Lang in 1860, and about twenty of them are still standing, being, I judged, about 35 feet in height. They were loaded with great clusters of nuts, which forcibly reminded me of pictures of the Orient. Every residence along the shore on either side is graced with cocoanut trees, and many persons are planting them by the acre. Whether or not this enterprise will prove a financial success so far as the fruit is concerned I am as yet unable to say, since the cocoanut is brought from the tropics by the ship-load so cheaply that it will be at least difficult to compete with the foreign product in our markets. However this may be, there is no doubt of the success of the growth of the cocoanut in this region. Hundreds of thousands of young cocoanut trees are growing along the coast and adjacent islands as far south as Key West.

It may not be generally known that the cocoanut, as it appears in our markets, is stripped of the coarse fiber or bast which surrounds it, and which makes a covering about 2 inches thick, with a smooth exterior. The nuts hang in large clusters of from ten to forty or even more, and several such clusters are found on a large tree, weighing in the aggregate some hundreds of pounds. The cocoanut has no fixed time of ripening, as the flowers keep constantly appearing and the ripe nuts dropping. Thrifty cocoanut trees are expected to produce each about one nut for every day in the year, but they rarely produce so many.

THE SAPODILLA (*Achras sapota*)

is an evergreen tropical tree. I saw it growing in several places, from Merritt's Island southward. The tree is very handsome, though

rather spreading in shape; the leaves are from 2 to 4 inches in length and of a glossy green. It bears fruit very abundantly, of roundish shape, slightly conical, and of a solid brown color, the surface resembling that of a dark russet apple. The flesh is of a light brown, varying to greenish white, and is exceedingly sweet and deliciously flavored. The seeds are rather numerous, usually numbering from five to ten, slightly elongated in shape, and of a shiny black color. The fruit can be easily shipped to market, where it brings a good price. Our entire supply at present is brought from the West Indies. The accompanying illustration (Plate 8) was made from a specimen grown by R. R. McCormick, of Palm Beach, Fla.

THE MANGO (*Mangifera indica*)

is one of the finest tropical fruits cultivated in the world. It has been introduced into many places in Florida, and trees have been fruiting there for a number of years. The freeze of January, 1886, killed many of them to the ground, but I saw several bearing trees along the shores of Lake Worth, and one on Merritt's Island. One tree about 10 feet in height, in Mr. Brelsford's grounds at Palm Beach, produced this year 1,106 ripened fruits, by actual count, besides a number which were taken without the knowledge of the owner.

The mango, being an evergreen tree, produces a pleasing effect either as a fruit or an ornamental tree, the leaves being from 6 inches to a foot long, resembling those of the chestnut in shape, and appearing quite glossy and brilliant in color. The growing shoots have a wine-colored tint, which adds to the beauty of the tree. It grows to a large size, and the wood is valued for mechanical purposes in the East Indies. All the varieties now fruiting in Florida are common seedlings and the fruit is much inferior to the choicer kinds, which are only propagated by grafting. A number of the best kinds have been recently introduced and it is expected that within the next few years our Northern markets will begin to receive the fruit. The fruit averages in weight from 8 to 10 ounces and is kidney-shaped, with a large flat seed in the center to which is attached a sort of fiber, especially in the common or poorer kinds; but the choice varieties are entirely free from this characteristic. The flesh is yellow and exceedingly sweet and aromatic in flavor. The fruit will always be rare and high priced in our Northern markets, but there is no reason why we may not produce a large share of the amount consumed by our people instead of importing it from the West Indies, as is now the case, while people living in tropical Florida may enjoy the fruit very generally. It is of a nature so delicate that it suffers decay during a long voyage by ship, but rapid transportation by rail from southern Florida will, in a great measure, overcome this difficulty. The tree seems quite well adapted to the poorer sandy lands and produces fruit abundantly even in such soil with reasonable culture.

THE BANANA.

The banana is grown in a small way in many parts of Florida; but only the poorest kind, known as the Orinoco or "horse banana," is able to withstand the frosts of the more exposed regions. The fruit when cut green and left to ripen on the stem is poorly flavored and scarcely fit to eat, but when left to ripen on the tree it is of fair

quality. Along the south end of "Indian River" and on the peninsula between Lake Worth and the ocean I saw many small plantations of the banana, but the variety usually cultivated is the dwarf species known to science as *Musa cavendishii.* This does not grow more than 4 to 6 feet high, and the "fingers" are comparatively small, but the quality is quite good although not equal to those we usually buy in our markets. The banana needs rich land and careful culture. There is very little land suitable to its growth in Florida, even if the climate was sufficiently mild, and I seriously doubt if banana culture will ever be carried on profitably except in a very small way.

Hart's Choice, a variety of *Musa orientum* is a very small growing kind which was brought into public notice by Mr. E. H. Hart, of Federal Point, Fla., and is sometimes called the "fig banana;" in quality it is the best I have ever tasted of the Florida product. This variety probably might be tested with profit by the amateur fruit-growers of southern Louisiana, southern Texas, and southern California.

Many other tender fruits are grown in the southern part of Florida, the culture of which will in due time attain considerable importance, and it is my purpose to mention some of them in future reports.

SEMI-TROPICAL FRUITS.

THE KAKI.

The confused condition of the nomenclature of this fruit for years past, both in Japan and in this country, is a matter of regret and annoyance to cultivators. Thousands of trees have been imported from Japan bearing the names of the best established varieties there, which have proved upon fruiting to be often incorrectly named. One case recently has come to my notice in which ten trees bearing the name of one of the leading varieties had been imported with special care, and when they fruited there were found to be three varieties, no one of which was that which the importer had sought to secure. In 1887 I was able to get specimens from the Southern States sufficient in number to enable me to determine the characteristics of three varieties, viz, *Hachia, Tane Nashi,* and *Yemon.*

Last year, owing to the prevalence of yellow fever in Florida (where a majority of the trees now fruiting are found), it was not possible to secure specimens either by mail or express, but during the present year we have been much more successful. A great quantity of the fruit has been received from every State and Territory in which it grows, and the matter has received close attention from first to last.

Having the benefit of original paintings made by Japanese artists, and descriptions of the different kinds given by pomologists of that country, and a considerable correspondence with them as well as with a large number of the principal growers and importers of the fruit in this country, I feel justified in saying that only about ten leading varieties are grown largely in Japan, all of which have been introduced and are now fruiting in this country. The above mentioned three varieties described in my report of 1887 are among the number, and the others are: Hyakume, Zengi, Yeddo Ichi, Yamato, Diadai Maru, Kurokume, and Gosho.

In the course of my examination and study of the different kinds of this fruit from different localities I have arrived at the following

conclusions: No variety is absolutely seedless under all circumstances, although seeds are fewest in those generally described as "seedless." I am informed by Rev. Mr. Loomis, of Yokohama, who has been a close observer of this fruit for many years past, that in Japan the Yemon is often quite seedy, but in this country it is rarely so. The Yeddo Ichi and Zengi are more inclined to be seedy than any other varieties (of those mentioned as "seedless") that I have examined, and specimens of Zengi have been sent me which were quite seedy, yet fruit of the same tree last year was almost devoid of seeds. I therefore conclude that this difference results from variation of the essential organs, the stamens sometimes being quite abundant and at other times wanting, or nearly so; or it may be the effects of cold or rain that destroys the pollen or prevents its falling on the pistillate flowers, or some other local cause that we have not yet learned. I have also observed *that the flesh is dark colored or flecked, with brownish purple streaks only immediately next the seeds.* Sometimes only one or two small seeds will be found in a specimen, and usually in such cases the flesh is darkened near them, and elsewhere it is orange colored with no brownish streaks. The very seedy varieties, such as Zengi and Yeddo Ichi, are always dark fleshed, and specimens of Yemon, Tane-Nashi, or others having no seeds, are light colored. It is also observed that the dark-colored flesh is not acrid or astringent while yet hard, but the light-colored flesh is astringent until soft. It will therefore not be correct to conclude because a specimen or a few specimens of a variety are seedless or seedy that the variety is universally so.

Hyakume (*Hyá-ku-mé*).—Plate 9 is an illustration of Hyakume, which is thought by many good judges to be one of the very best varieties. In size it is one of the largest, single specimens sometimes weighing a pound or more. The literal translation of Hyakume is "one hundred *mé*," the word *mé* being a unit of weight in Japan, and a hundred *mé* being about equal to one pound according to our standard of weight. In color the fruit is light orange and not so dark as some of the other varieties. Near the apex a number of marks like pin-scratches or leather cracks are usually found, which are shown in the illustration. It is elongated and slightly conical in shape, but is depressed and somewhat furrowed at the point. In flavor it is excellent. The tree is commonly said to be an abundant bearer and attains a good size. The illustration given in this report was made from a specimen received from T. K. Godbey, Waldo, Fla. Seeds are occasionally found in this variety, and their length is about twice their diameter.

Yeddo Ichi.—Literally translated "First from Yeddo," but changed into our English form it is "Yeddo's Best." It is medium sized, flat in shape, regular in outline, with a slight depression at the point opposite the stem. It is bright red in color, being among the darkest varieties known. The flesh is universally dark-brownish purple throughout. The flavor is exceedingly rich and sweet. The seeds are usually quite abundant and well developed and are about like a lima bean in shape. The tree is said to be an abundant bearer, and is among the hardiest varieties introduced.

The specimens from which the colored illustration (Plate 10) was made were received from G. L. Taber, of Glen St. Mary, Fla.

FUTURE WORK.

It is my purpose to continue the investigation of the wild fruits, as I believe there is a vast store of wealth in them. This is especially true of the wild grape, plum, and many of the smaller fruits. Following the monograph on the wild grape will be undertaken one on the wild plum, covering the entire genus *Prunus* as it is found in the United States. The investigation, collection, and publication of concise information relative to wild fruits in their native habitats and the peculiar conditions under which they succeed or fail as well as the possible discovery of valuable varieties will, in my opinion, be of great benefit to fruit-growers as well as of interest to scientists.

In foreign countries, and especially in Asia, there are many varieties and even species and genera of fruits which have not been tried in this country. Many of these will no doubt prove of great value to our people, especially in the Southern States. In Europe it is probable that there is little that is new to be found in the line of fruits, as that continent has already been thoroughly explored by both scientific and practical men, and nearly everything worth having has already been tested in this country. It is possible, however, that there may be some varieties in eastern Europe suited to the cold climate of our Northern States and Territories, while in the Mediterranean regions there may no doubt be found some varieties of citrus fruits and figs which will add to the list of our choice varieties.

It is much to be desired that there should be a hearty co-operation between this division and the national, State, county, and local horticultural and pomological societies, and with the experiment stations, and it is a matter of regret that the appropriations heretofore have been insufficient for carrying out such plans on a practically useful scale. For the same reason the services of special agents were available only in a very limited degree, and had frequently to be dispensed with even when urgently required.

I have in course of preparation a list of known varieties of cultivated fruits grown in the United States, giving the correct or true name, and all the synonyms attached to each. The issue of this will be preceded by a series of circulars of inquiry as to the success or failure of each in the localities where they are cultivated. Questions will be asked as to the hardiness of the tree, plant, or vine, as the case may be; the productiveness, or the want of it; the exemption from attacks of fungus diseases; insects; the time of ripening, and other questions of a practical nature. From data thus obtained from practical men I shall be able to prepare special reports which, it is hoped, will be of practical value to fruit-growers and farmers. It is inexpedient to enlarge further upon plans which may have to be abandoned for lack of sufficient appropriation; but so far as circumstances will permit, farmers and fruit-growers will find in this division a faithful servant and ally in the line of work confided to it.

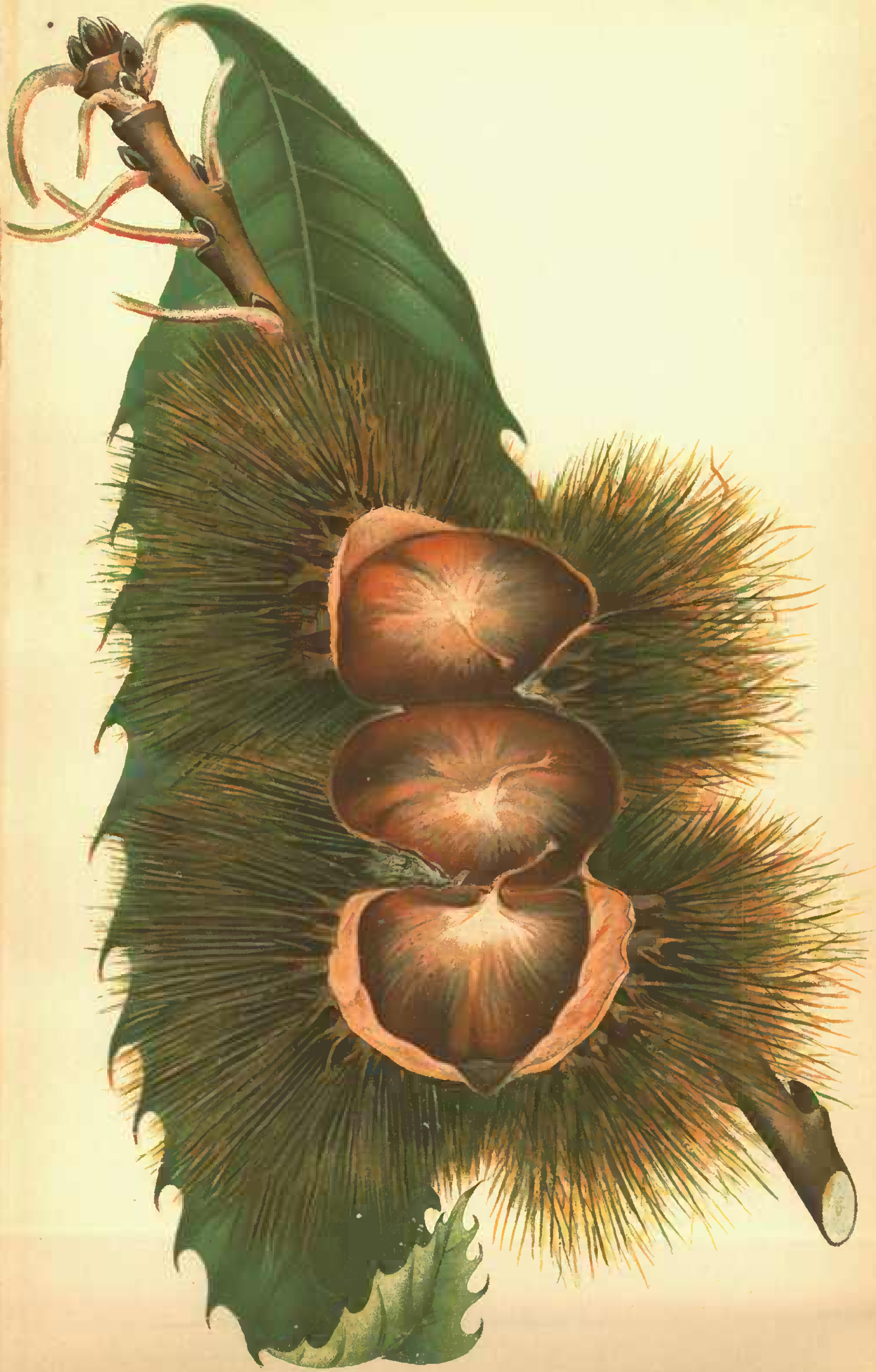
Respectfully submitted.

H. E. VAN DEMAN,
Pomologist.

HON. J. M. RUSK,
Secretary of Agriculture.

EXPLANATION OF PLATES.

REPORT OF POMOLOGIST.

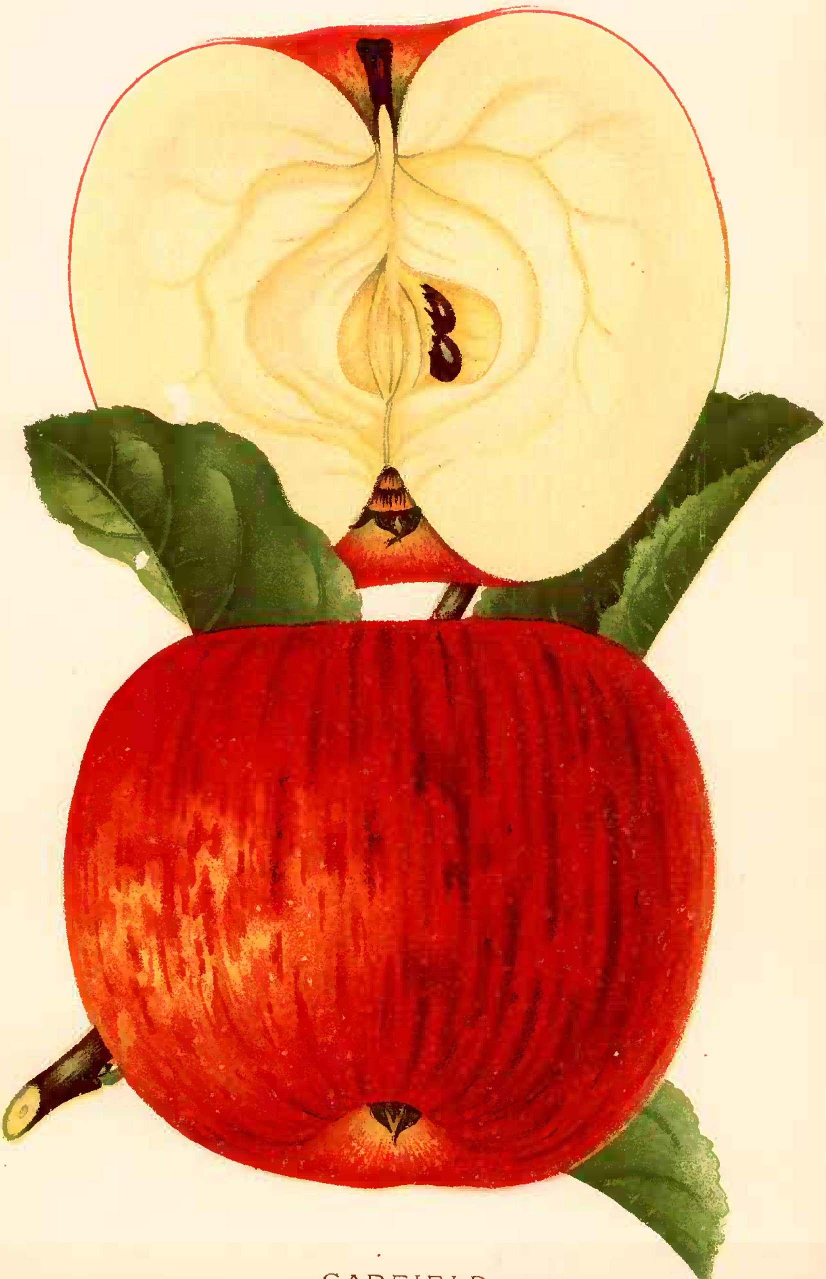


PARAGON.

HAWKEYE.

Wm H. Prestele, Fecit. Geo. S. Harris & Sons, Lith. Phila.

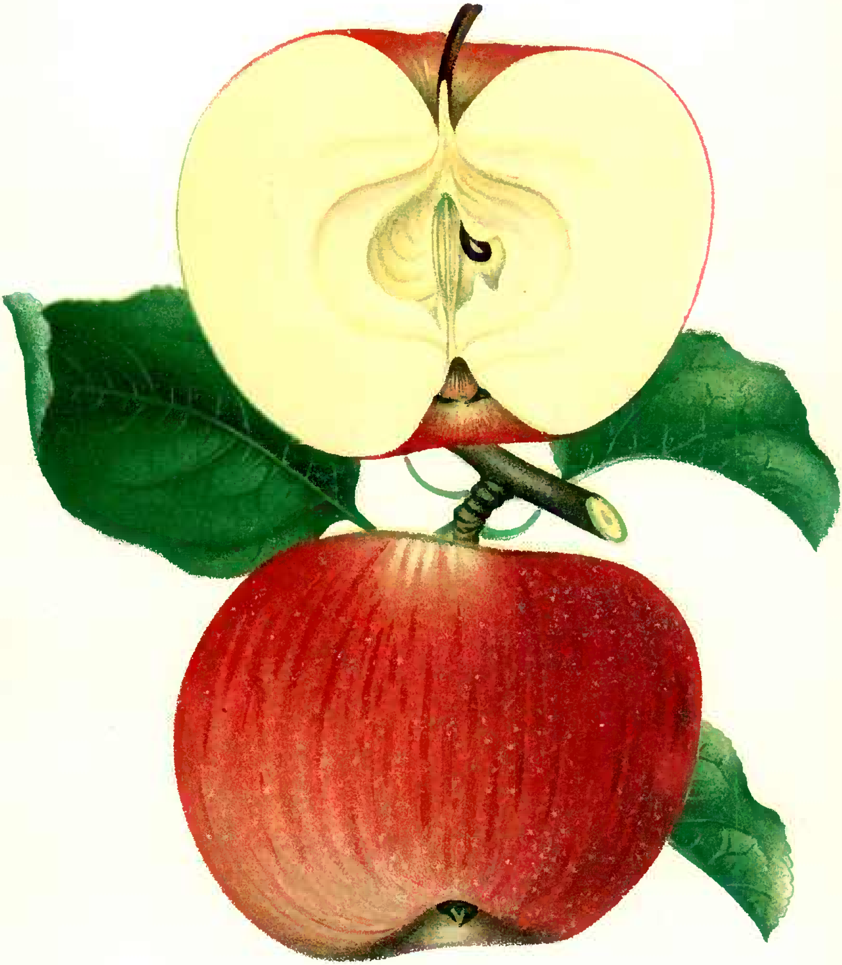
CRANDALL.



GARFIELD.

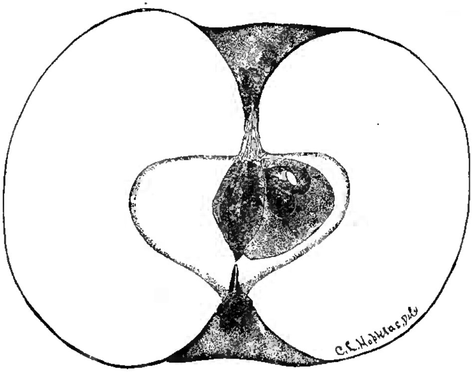
Wm H. Prestele, Fecit.

Geo S Harris & Sons, Lith. Phila.

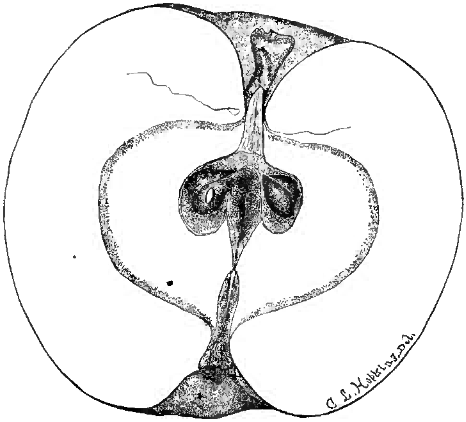


WINDSOR.

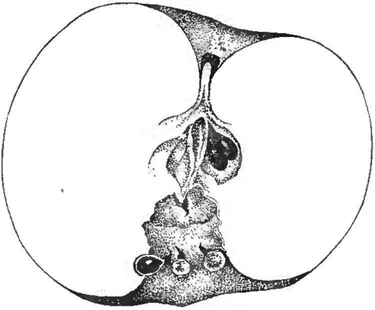
Wm. H. Prestele, Fecit. Geo. S. Harris & Sons, Lith. Phila.



LACON.

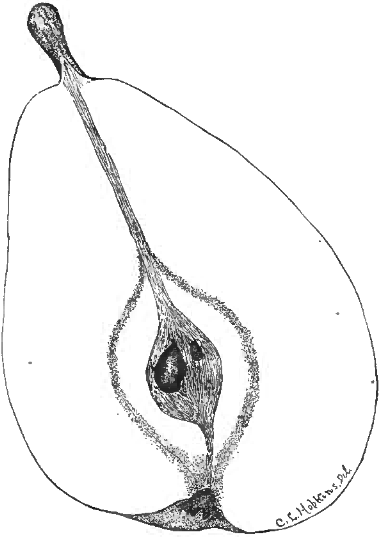


PEFFER.



CORELESS AND SEEDLESS APPLE.

(So-called.)

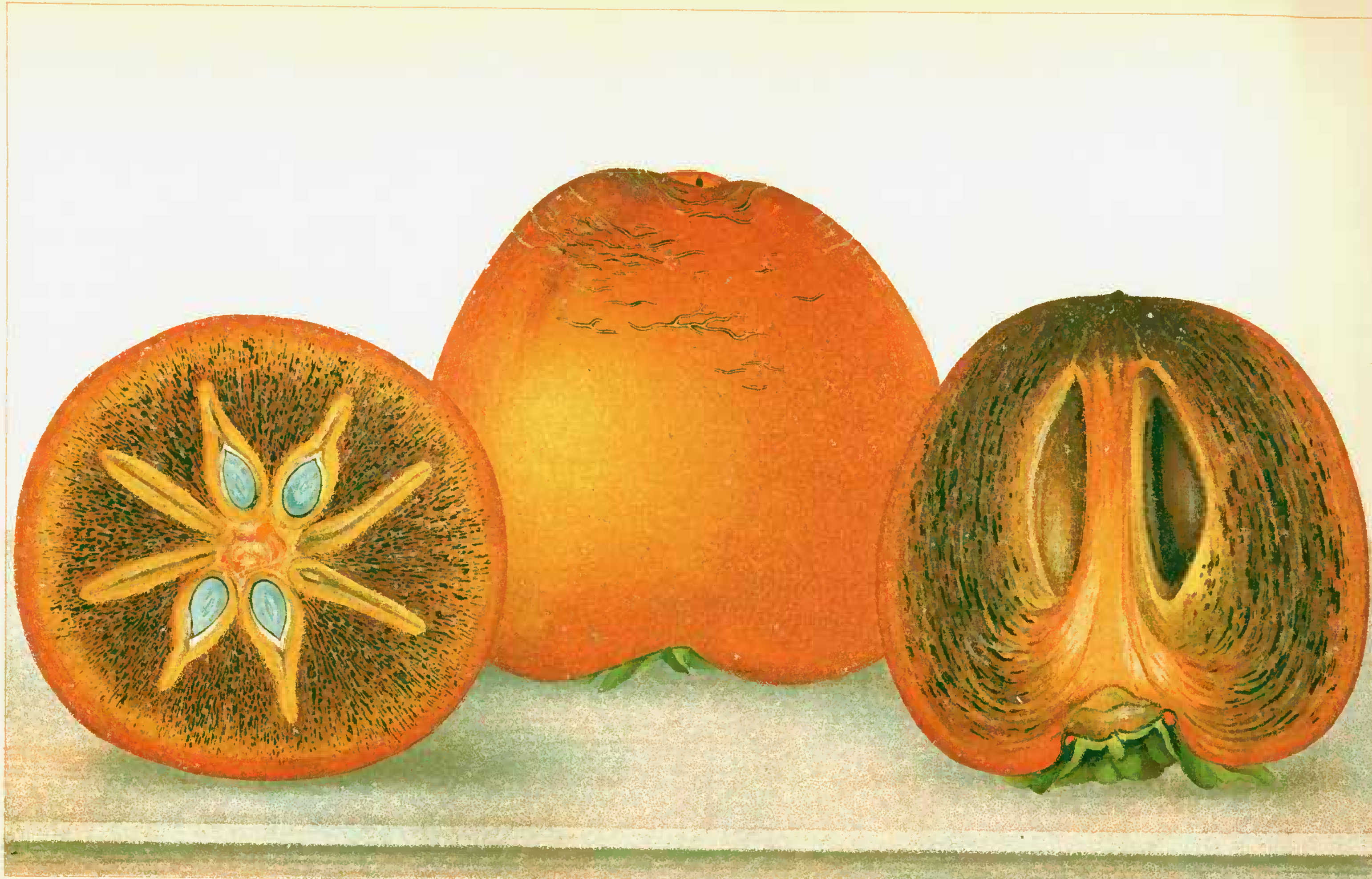


PHILOPENA.

SAPODILLA

Plate IX

Report of Pomologist U S Dept of Agriculture 1889

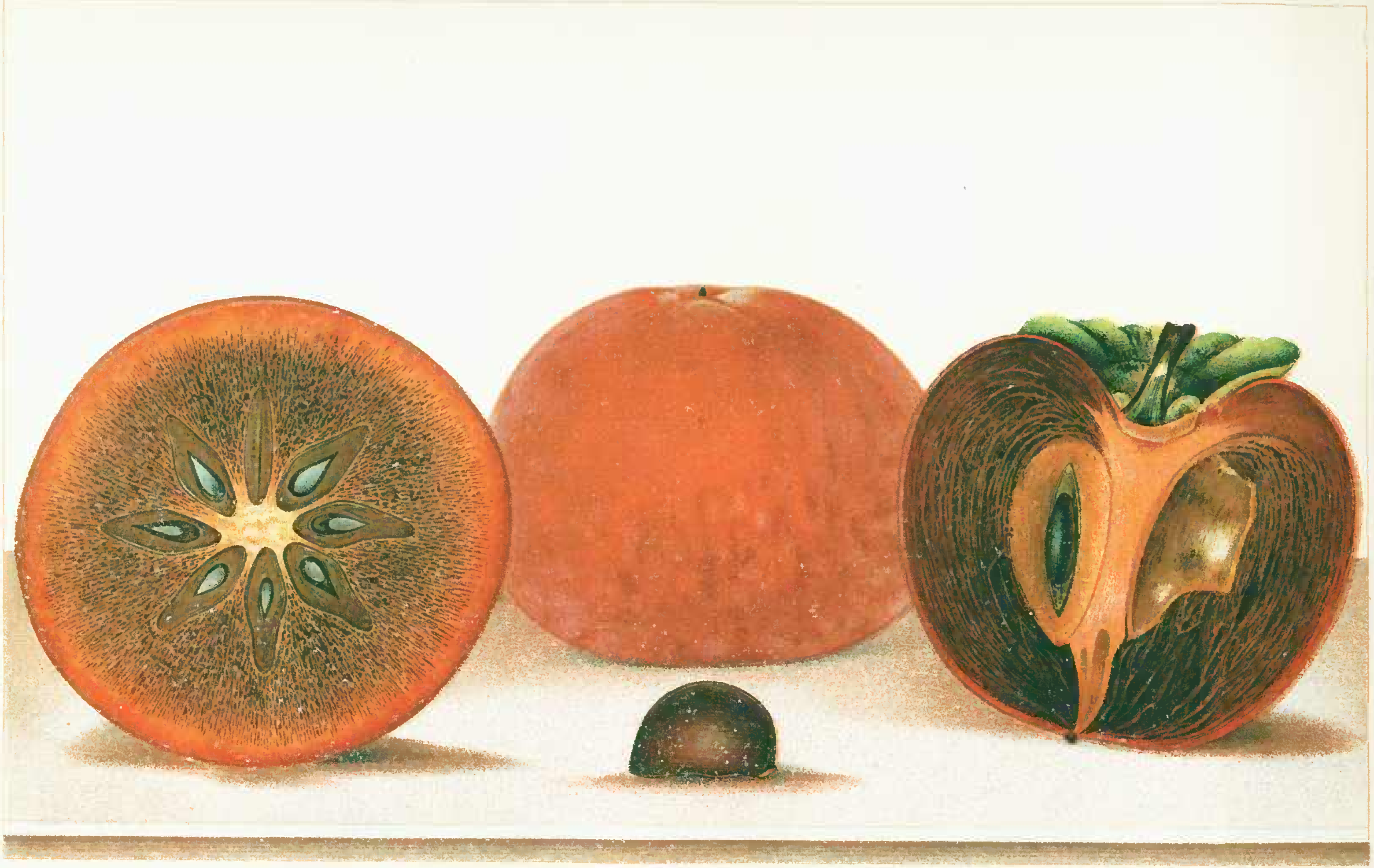


HYAKUME

S Harris & Sons

Plate X

Report of Pomologist U.S. Dept of Agriculture 1889



Wm H. Prestele, Fecit.

YEDDO ICHI.

Geo. S. Harris & Sons, Lith. Phila.

REPORT OF THE SILK SECTION.

SIR: The Silk Section having, by your order of October 28, 1889, been severed from the Division of Entomology, with which, by direction of the Commissioner of Agriculture, it had been connected since the beginning of the period of regular appropriations made by Congress in 1884, it becomes my duty to submit to you directly my first annual report as its chief.

Yours respectfully,

PHILIP WALKER,
Chief of Silk Section.

Hon. J. M. RUSK,
Secretary of Agriculture.

REPORT.

The general plan of the work done by the section has been the same during the past year as in those already reported upon. There have been received in this office and duly replied to five thousand four hundred and forty-eight letters during the calendar year 1889. The greater portion of these letters have been simple requests for supplies, which have been answered by circulars or by letters which have not involved any great amount of labor.

AUTOMATIC SILK REELS.

The principal work of the office, and that which has entailed the most labor upon me personally, has been the study and improvement of automatic reeling machinery. The Serrell reel being the only automatic silk reel in existence, there was no option on the part of the Department as to whether it or another should be adopted as the basis of our experiments. At the time of making my last report, the experimental silk filature was at a standstill because the machine of which we had secured drawings from Europe had not succeeded as well as we had hoped, and experiments were then being made with a view to making it work. There are two main parts of the automatic silk reel.* The *control movement* measures the thread and, when the latter becomes too small, sets in operation an electric current by which the *feed movement* is put in motion and a cocoon added to the thread. The first object of my experiments was to produce a feed movement which should be absolutely automatic and do away with the great labor entailed by filling by hand the magazines used in the original automatic reel. This object is in a fair way of being attained and a feed movement which appears to work well has been constructed. The control movement made during the previous fiscal year, while it worked to a certain degree of satisfaction, was not all that could be desired, and a new one has

* See Bull. No. 14, Division of Entomology, Washington, 1887, p. 52.

therefore been designed which does much better. Some details may yet be found, doubtless, which will need correcting, but as far as can be seen the main difficulties have been overcome.

The improvements mentioned do not in any way involve change in the principle of the invention; they are improvements of mechanical details only, the principle of the original automatic machine having been adhered to. That a thoroughly automatic silk reel is a possibility I feel confident. It is desirable to make a thorough trial of the reels as now constructed and that improvements of details should be continued until a machine is designed which will be as nearly perfect as possible in the performance of its functions, simple in its mechanical details, and not liable to get out of order. Under existing instructions my purpose is to follow out a line of experiments tending towards this end.

The experiments which the Department is making with automatic machinery have the following object in view: At present, owing to the superior price of labor in the United States, a manufacturer, in order to conduct the reeling business profitably, can only pay for his cocoons a price even lower than that paid in Europe to the peasant silk-raiser. To remedy this state of affairs and equalize by improved machinery the difference in wages, thus making it possible for the manufacturer to pay a better price for the raw material, is the solution or at least a partial solution of the silk raising question, and to this end the present experiments are directed. This involves no competition with commercial enterprise in the work of reeling, but, if successful, our work can not fail to greatly, though indirectly, aid the agricultural classes. The work so far has consumed more time than was anticipated at the outset, but from the present outlook there seem to be good grounds for believing that the outlay both in money and time will be amply compensated by the results. So much for this one means of aiding the silk producer. For the other means, the silk-raiser must look to the principle so often expressed by yourself, of equal protection to the producer and the manufacturer.

DISTRIBUTION OF SILK-WORM EGGS.

The custom of the Department of distributing silk-worm eggs was continued during the season of 1889. About five hundred and seventy-five ounces of eggs were thus distributed in twelve hundred and seventy-one lots, in forty-one States and Territories, as follows:

State or Territory.	Lots.	State or Territory.	Lots.
Alabama	44	Minnesota	4
Arizona	1	Mississippi	11
Arkansas	30	Missouri	68
California	4	Nebraska	22
Colorado	2	New Hampshire	2
Connecticut	4	New Jersey	12
Dakota	2	New Mexico	1
Delaware	13	New York	28
District of Columbia	3	North Carolina	46
Florida	51	Ohio	140
Georgia	33	Oregon	1
Illinois	81	Pennsylvania	47
Indiana	46	South Carolina	26
Indian Territory	2	Tennessee	17
Iowa	29	Texas	64
Kansas	228	Utah	21
Kentucky	23	Virginia	38
Louisiana	20	West Virginia	24
Maine	1	Wisconsin	7
Maryland	37		
Massachusetts	10	Total	1,271
Michigan	28		

The distribution embraced the following races: French, Deydier (Cevennes race); Italian, Mercolini (Marches race), Pucci (two Umbrian races). So far as we have received reports from the persons who reared the worms coming from these eggs we have every reason to be satisfied with their quality. A new supply of them has therefore been purchased this year together with a few additional varieties which it seems advisable should be introduced into the United States. At the same time the quantity has been increased, in proportion to the increased demand for the eggs, from 500 to 800 ounces. The races which have been purchased this year are as follows:

	Ounces.
French:	
Deydier (Cevennes race)	200
Ribaud l'Ange and Gorde (Lower Alps race)	100
Aubin (Improved Var race)	100
Forné (Pyrenees race)	100
Italian:	
Mercolini (Marches race)	100
Pucci (Umbrian race)	100
Mari (Ascoli race)	100

These eggs have the same general characteristics, being annual and producing medium-sized yellow cocoons of fine texture.

The objects of these gratuitous distributions of silk-work eggs are twofold. First, they are destined to assist persons who wish to begin experiments in silk culture and who would not know where to purchase reliable eggs; and second, for the purpose of introducing silkworm eggs of known varieties and first quality into the United States. The results of these distributions have been to materially improve the quality of the cocoons produced in the country, as shown by the lots which are sent to the Department for sale.

THE COCOON CROP OF 1889.

The falling off in the cocoon crop of the country in 1888 was compensated in 1889 by a recovery to about the production reported for 1887. It will be remembered that the cocoons accredited to the latter year had many of them been produced in previous seasons, and therefore the production of the past summer shows a healthy increase. The purchases of the three years are as follows:

Year.	Dry. weight.	Fresh weight.
	Pounds.	*Pounds.*
1887	6,174	18,522
1888	3,913	11,739
1889	6,248	18,745

In the past the crop has been reported by dry weight, as most of the cocoons were purchased in that condition. It is usual, however, in Europe, to report fresh weight, and that system will be followed in these tables. In reducing from fresh weight to dry it is only necessary to divide by three, and to get the equivalent price for dry cocoons to multiply by three.

The crop of 1889 was purchased as usual at the following filatures:

	Lbs.	Oz.
Washington	11,805	14
Philadelphia	3,002	03
Peabody, Kans	3,936	08
Total	18,744	09

The number of persons corresponding with this office in relation to the sale of cocoons increased materially. In 1887 there were three hundred and sixty; in 1888 four hundred and ninety-eight; and in 1889 seven hundred and forty-one, five hundred and sixty-two sending lots and one hundred and seventy-nine only samples. The average value of each lot received was $6.27 as against $4.53 in 1888. The average weight (fresh) of each lot was 20 pounds, and the average value per pound (fresh) 30 cents (dry equivalent, 90 cents). Seventy-one persons were paid $10 or more for their cocoons, while in 1888 only fifty-eight were so compensated.

Of that number two of the parties, who received respectively $237.74 and $252.67, included in their lots the product of several individuals. All the other lots are believed to have been raised by the individual seller. The highest sum paid for any such lot was $146.05, paid to Mrs. F. J. Adams, Montserrat, Johnson County, Mo., and the next highest, $91.85, paid to Miss Mary Adams, of the same place. The total amount paid for the seventy-one lots was $2,024.32, an average for each lot of $28.51.

The crop was purchased in the following States and Territories:

	Washington.		Philadelphia.		Peabody.		Total.	
	Lbs.	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*
Alabama	170	10	19	02			189	12
Arkansas	121	08					121	08
California	799	08					799	08
Connecticut			5	00			5	00
Delaware			11	04			11	04
District of Columbia	113	07					113	07
Florida	282	06	126	12			409	02
Georgia	187	02					187	02
Illinois	860	08	151	09			1,012	01
Indiana	597	06	221	07			818	13
Indian Territory	22	08					22	08
Iowa	195	07	4	08			199	15
Kansas	1,452	12	20	13	3,767	00	5,240	09
Kentucky	265	08					265	08
Louisiana	127	08					127	08
Maryland	144	10	15	00			159	10
Massachusetts	129	00	5	02			134	02
Michigan	123	06	140	13			264	03
Minnesota	66	00					66	00
Mississippi	36	00					36	00
Missouri	1,768	08	840	11	169	08	2,778	11
Nebraska	418	14					418	14
New Jersey	10	08	15	15			26	07
New York	128	13	3	00			131	13
North Carolina	367	10					367	10
Ohio	1,464	03	863	00			2,327	03
Pennsylvania	329	01	368	13			697	14
South Carolina	345	03	35	13			381	00
Tennessee	175	05					175	05
Texas	467	07	18	06			485	13
Utah	388	10	1	13			390	07
Virginia	144	10	34	03			178	13
West Virginia	102	00	18	00			120	00
Wisconsin			81	03			81	03
Total	11,805	14	3,002	03	3,936	08	18,744	09

It is perhaps worthy of comment that 2,786 pounds of cocoons were produced in Marion County, Kans., where Peabody is situated.

STATIONS FOR THE PURCHASE OF FRESH COCOONS.

A serious difficulty which has been met with in the operation of the experimental silk filature at Washington is due to the fact that silk-raisers have not been able to find a market for their cocoons when fresh and before stifling. They have therefore been obliged to stifle them with such means as they have had at their disposition, in small quantities, and after they have become dry to ship them to the filature. Cocoons which are produced in June are therefore not mark-

etable much before the 1st of September, and the silk-raiser has thus been placed in the abnormal condition of being obliged to wait for the money for his crop until three months after its production. It has long been the desire of the Department to ameliorate this condition of affairs, and with this object in view I was last spring ordered to proceed West to those parts of the country where the largest quantities of cocoons were produced, and ascertain the most advantageous points in which purchasing stations, supplied with proper stifling apparatus, might be placed. Under these orders I visited Kansas, Missouri, Illinois, Indiana, and Ohio, and as a result submitted a report in favor of establishing a station at St. Louis as well as one among the Mennonites of central Kansas. The former station was established with Mr. Henry L. Judd, of St. Louis, in charge. Another was ordered to be established at Newton, Kans., but in view of the proximity of the Kansas State Silk Station, at Peabody, but 20 miles distant, it was (upon representations made to the Department by the State Board of Agriculture) determined to discontinue it. The station at St. Louis was opened on the 1st of June and purchases were made there until the middle of July. It occupied a hired room where steam from a stationary boiler was available. The station was supplied with a simple steam-stifling apparatus which had given satisfactory results upon being tested in Washington. The purchases made by this station were limited to the States of Missouri and Illinois. As a result there were bought 246 pounds of fresh cocoons from Illinois and 494 pounds of fresh cocoons from Missouri. The total (740 pounds) was not large, but this is possibly due to the fact that it was determined to establish the station just at the opening of the sericultural season and it was not sufficiently well known that cocoons would be purchased by the Government in this manner.

As an example may be cited Barry County, Mo., where 632 pounds were produced too late for shipment to the station, and Johnson County, Mo., which produced 874 pounds, which were purchased dry by the Department later in the year. It is hoped that a continuation of work in the same line will give better results. The cocoons purchased at St. Louis have thus cost the Government much more than they would had they been purchased in the ordinary way, especially as the Department in this case paid for the transportation of the merchandise; but on the other hand the raisers of the cocoons received their money very much earlier, and the cocoons as they reached the Department were in very much better condition. As this report goes to press none of the first quality cocoons received from St. Louis have yet been reeled. The second quality cocoons have been tested to some extent and in general they reel very much better and more regularly than lots of cocoons stifled as heretofore.

So far as this trial goes, the result, while not all that was to be hoped for as to quantity, is otherwise satisfactory, and may be regarded as a material step in advance in the establishment of the silk industry in the United States.

REARING OF SILK WORMS AT WASHINGTON.

A facility hitherto lacking in this section was supplied last spring by the erection of two rooms prepared for the raising of silk-worms. They were constructed in the museum building of the Department, adjacent to the experimental silk filature. The ground-floor room accommodates the worms from one ounce of eggs, and the second floor those from one ounce and one-half. It was the intention in

building these two rooms that the lower one should be accessible to the general public, which has always evinced great curiosity in the raising of the worms, and that that on the second floor, which was not so accessible, should be used for the more careful experiments necessary in scientific researches. One point which we wished to determine especially was the real value of the Osage orange as compared with the mulberry. Our room is so constructed that parallel lots of worms can be fed on the two foods under as nearly as possible similar conditions. With this object in view there were incubated one-half ounce each of three of the races distributed by the Department. One-half of each lot was fed upon the Osage orange leaves picked from the hedge which surrounds the Department grounds, and the other upon leaves picked from white mulberry trees scattered throughout the suburbs of Washington. It is impossible definitely to decide the variety of these mulberry trees, as they have probably been of spontaneous growth, and date from the multicaulis epoch. They are not, however, multicaulis trees, but more like the rosea. The hedge of Osage orange around the Department grounds is an ornamental one, which is trimmed twice a year. The leaves which are picked from it early in the spring are therefore very succulent and hardly fit for food for the silk-worms. The result of my trials was, consequently, that I lost practically all of the worms that were fed upon maclura. It might have been expected that they would succumb to flaccidity due to the excess of water in the food, but this was not the case, as there were very few flaccid worms in the whole lot, no more than among those fed upon the mulberry. It was, on the other hand, the *grasserie* which decimated the worms and which began to appear after the third molt, and as a result hardly any of them spun cocoons. The mulberry-fed worms remained remarkably healthy, and produced, for each quarter ounce, for the Cevennes race 33 pounds of fresh cocoons, and for the Umbrian and Marches races 34 pounds each. It will be seen that this is at the rate of 132 and 136 pounds respectively per ounce.

Through the courtesy of the chemist I had placed at my disposition the services of Mr. E. A. v. Schweinitz, one of his assistants, who carefully followed all of the physiological experiments which I was performing with the silk-worms and made some chemical analyses which, while not as complete as we ultimately intend to make them, still have a certain value to sericulturists. Mr. Schweinitz's report follows my own. He took as a basis the examinations and analyses made by Monsieur Peligot several years ago in France when the mulberry was used as the food. It was then very accurately determined that the principal chemical constituents of the leaves which enter into the nourishment of the worm are phosphoric acid, magnesia, and potash, and that the principal portions of the leaf not digested, but passed off in excrement, are silica and lime. Mr. Schweinitz will show that the valuable constituents are found in the leaves of the maclura to a greater extent than in those of the mulberry, while the lime and silica exist to a less degree. It is hoped that these experiments may be followed out with greater success another year and that the results will be somewhat more definitive.

One result accomplished was in satisfying ourselves that the eggs which were purchased by the Department and distributed to silk-raisers were of a very satisfactory quality. The renditions noted above were far better than we have been in the habit of expecting and were an indication of the great improvement which is going on

in the quality of the races of silk-worms which are now cultivated in Europe and which the Department is introducing into the United States. Some of the cocoons which we raised from the Italian stock have been compared with cocoons raised from the same stock in Italy. The result shows that the climate has greatly improved the texture and quality of these cocoons, a circumstance not unusual when eggs are taken to a foreign country. I have succeeded in obtaining samples of the eggs of some of the cruder races of silk-worms, which I propose to test next spring with a view to studying the effects which such a change of climate may have upon them.

INDEPENDENT ORGANIZATIONS.

By a new act the Kansas State Silk Commission was abolished about a year ago and one commissioner, Dr. L. A. Buck, of Peabody, appointed in its stead. He has followed the line of work inaugurated by the commission.

The State Board of Silk Culture of California failed to obtain an appropriation last year, owing to the veto of the governor. They therefore sent out a circular stating that they would not purchase cocoons. This was followed by one by the Ladies' Silk Culture Society, offering to take up the crop, but it did not prevent the destruction of many eggs. It is thought that the board will be reorganized next year on a new plan.

The Ladies' Silk Culture Society of California has continued work under a Congressional appropriation of $2,500. They have continued their experimental work at Piedmont and the propagation and distribution of mulberry trees. Their report to Congress has been published as an executive document.

The Women's Silk Culture Association of the United States has continued the operation of the filature at Philadelphia. During the season they conducted experimental educations of silk-worms at Fairmount Park. They have during the last fiscal year distributed nearly eighteen thousand mulberry trees in twenty-eight States. The association has received an appropriation of $5,000 for the present fiscal year. Its report has also been submitted to Congress and printed.

INVESTIGATIONS IN EUROPE.

Under your instructions of April 23 I proceeded to Europe about the middle of June to investigate certain questions of interest and importance to the sericultural work of the Department. The matters to which you particularly directed my attention were: First, any important exhibits in the Universal Exposition at Paris; second, the Government establishments for the advancement of silk raising in European countries; third, establishments, either public or private, for the production of silk-worm eggs; and fourth, the investigation of any new automatic silk-reeling machinery which might be adopted in the United States with advantage to the industry here.

In pursuance of these instructions I repaired to Paris and made such investigations as were possible in the exposition. I regret to say that I there found almost nothing of interest or remarkable for novelty. One silk filature in operation was exhibited by the establishment of La Buire, of Lyons, but it had no automatic features and possessed no new points. There were exhibited in the Italian section

some reels of a pattern very commonly found in Italy, but which, in addition to being non-automatic, suggested no new ideas which could be made of value in the United States. The sericultural exhibits were very insufficient and, doubtless owing to their destructible nature, in rather bad condition. They served for little, except perhaps to indicate the names of some of the larger egg producers whom I visited afterwards.

I attended during my stay in Paris the sessions of the sericultural section of the International Congress of Agriculture, and met there several prominent French silk culturists, as well as others from Russia and the Levant. It was to be regretted that the arrangements for the congress were such that neither Italy, the greatest sericultural country in Europe, nor Austria, nor Spain were represented. The questions discussed were not at all of an international character, but such as concerned especially the interests of silk culture in France.

THE USE OF OSAGE ORANGE IN EUROPE.

One matter of interest which came before this section of the congress was the adaptability of the Osage orange (*Maclura aurantiaca*) as a food-plant in France and Italy. In certain portions of France the mulberry has been attacked by a fungus growth which appears upon the roots. The soil seems to be impregnated, and new trees planted in the same ground are immediately attacked by the disease. It was thought by some of the gentlemen present that the maclura might resist these attacks just as the American vine transported into Europe has resisted the attacks of the phylloxera. It was also thought possible that, once the maclura had been planted and attained sufficient size, the mulberry might be grafted upon it and a hardy plant, which would resist the attacks of the fungus, might be obtained, and at the same time a continuation of mulberry feeding be indulged in. In order to prosecute these experiments the sericultural station at Montpelier recently procured one thousand small plants of the maclura from America, and the result of the attempt of the horticulturist to graft the mulberry on the maclura will be looked for with interest.

In this connection I may say that the director of the experimental station at Padua has interested himself in the introduction of the maclura into Italy, not as a substitute for the mulberry, but as a plant that may supplement the mulberry and being more hardy possibly resist the attacks of late frosts with a greater degree of success. The silk-raiser having a few of these plants would be able to obtain food for his worms in case the first buds of his mulberry trees were injured.

MULBERRY TREES.

One branch of research which has a great importance for sericulture in the United States was a study into the different varieties of mulberry trees which are in use in Europe. At the exhibition there was nothing of this kind in the horticultural show proper. In the Tonquin exhibit there were shown a few plants of a mulberry, the leaves of which were very much like the nigra, which it was proposed should be sown and the stems cut with a scythe and the leaves fed to the worms on branches. It was argued by the exhibitor of these trees that they could be fed to four or five successive crops per annum, though he did not seem to have considered the fact that polyvoltin races are unprofitable.

I found in looking over the ground that there were very few of the great nurserymen of France who made any pretension of keeping a supply of mulberry trees. The firm that was best stocked was that of Jacquemet-Bonnefond, of Annonay, in the department of the Ardèche. They have nurseries in several localities, and at Andancette I met Monsieur Dusert, the present head of the house, who showed me the supply which he had on hand. In his estimation the *rosea* mulberry is the best food for silkworms, and it is that variety that is used throughout the sericultural districts of France. From a nurseryman's point of view he considered it better to graft it upon the *Lhou* or Japanese mulberry. One hundred of these trees so grafted have been purchased for the use of the Department.

At Milan I revisited the Cattaneo nurseries referred to in a former report. I had hoped to find in that city the plantation mentioned by Signor Cantoni in his work on agriculture in Italy. I learned, however, that the property occupied by the Royal College of Agriculture for this purpose, and which was under the control of the ministry of war, had been withdrawn from the college, and owing to this forced removal at an unpropitious season all their fine mulberry trees, vines, and other specimens of great value had been lost. At Andancette there were, however, a number of small trees, specimens of the different varieties of mulberries which were in the Cantoni plantation, so that they can be duplicated if necessary for scientific work.

EUROPEAN SERICULTURAL STATIONS.

The first Government institution which would ordinarily have been inspected was that at Montpelier, France, but on account of the serious illness of the director, Monsieur Eugène Maillot, I was obliged to return to this country without having visited it. I regret to be obliged to add that the illness which thus prevented my trip to Montpelier resulted in the death of Monsieur Maillot and in the consequent loss to French sericulturists of one of their leading scientific men. The French station, however, is perhaps the least important of those in Europe.

The most important of them is that at Padua, in Italy, which has already been referred to in the annual report for 1887 (p. 118). The following information in addition to that already published was obtained during a visit to Padua this summer. The course of study given during the spring of each year is destined to thoroughly acquaint practical silk-raisers with the scientific phases of their industry. To attain this end they are instructed in the use of the microscope, in the anatomy and physiology of the worm, and in the different methods of rearing silk-worms. The classes consist, annually, one of about twenty men and the other of about twenty women. The course of the former lasts three months and of the latter only about six weeks, the women's instruction in anatomy and physiology being less extended. At the end of the season an examination is held and a certificate of efficiency is accorded to those who are successful. Subordinate to the Padua station are sixty observatories, the directors of which must have a certificate of efficiency from the Padua station. They are given by the Government a microscope, an incubator, a hibernator, and some other minor necessaries, valued in all at about 600 francs ($120) for each observatory. Not more than five of these observatories are created annually. The revenue of the Padua station amounts to about 17,000 francs ($3,400) per annum.

The establishment at Goritz is devoted to the study of questions relating to wine culture as well as those connected with the culture of silk. Owing to the great prevalence of the diseases of the grape in Austria-Hungary the station is at present principally occupied with the viticultural side of its labors and its sericultural work is confined mainly to instruction given annually to silk-raisers in the scientific features of sericulture. Upon the death of Herr Haberlandt his assistant, Herr Johann Bolle, succeeded to the direction of this establishment. The station is situated very near the Italian frontier and in a portion of Austria where Italian is the principal language spoken; on the other hand it works largely in the interest of silk culture in Hungary and as a result the publications of the establishment are made both in German and Italian. I succeeded in obtaining for the library of the Department a valuable collection of these publications, dating back to the inception of the station. My memoranda upon the work being done for the establishment of silk culture in Hungary have been incorporated in a note following the body of this report.

With your authority I purchased from Herr Bolle a set of his valuable plaster models showing all the metamorphoses of the silk-worm and the more important phases of its diseases. These have recently been received from Goritz and placed in a suitable position in the museum of the Department. The Department has during the year also received five large lithographic charts, showing the same objects, which were presented by Signor Verson, director of the Italian station at Padua.

In addition to these three stations one has been established by the Russian Government at Tiflis, in Trans-Caucasia, but as it was not included in my letter of instructions I did not visit it and am unable to give any especial information with regard to its scope and management.

EUROPEAN SILK-WORM EGG PRODUCERS.

It is of the greatest importance to all silk-raisers that they should be able to obtain silk-worm eggs of the very best quality, entirely free from disease, and, as I have previously said, of such races that the cocoons may be easily marketed. Not the least important, therefore, of my duties while abroad was to study the races of silk-worms raised in Europe, to determine as nearly as possible who were the most reliable dealers in silk-worm eggs and to study their methods of production by personally visiting their establishments. The great number of these producers and the wide range of country in which they are located made it impossible that even a fair per cent. of them should be visited, and I was therefore obliged to examine what appeared to be the best establishments of the different districts of France and Italy. The most important egg-producing department in France is the Var, situated in the southeastern portion of that country. North of it is the department of the Basses Alpes, which stands second to it in the importance of its production. At the other extremity of the country, upon the Spanish frontier, are the Oriental Pyrenees, while more centrally situated, on the right bank of the Rhone, is the country generally designated as the Cevennes, covering the departments of the Ardèche and the Gard. In Italy the most important egg-producing districts are situated in the Marches, in Umbria, and in Tuscany. In France I have this year visited and

personally inspected thirteen different establishments situated in different portions of the country, and in Italy five establishments similarly situated. With one exception, that of Paul Deydier, of Aubenas, I found no pretension among the French egg producers of strictly following the Pasteur system of selection in all of its details. Most of the raisers prepare their "reproduction eggs"* in this manner, while those intended for sale to the ordinary consumer are laid upon cloth as they were before the days of the pébrine epidemic.

Another habit is growing in France, and that is the sale of silkworm eggs in cells. In the Var and the Alps the greater proportion of the eggs so sold were destined for Italian dealers. They take the moths with the eggs in the cells to their own establishments and have the former microscopically examined. The education from which the eggs are produced is always watched by the agent of the buyer and he thus satisfies himself of the freedom of his stock from diseases other than pébrine. By buying the eggs in the cells rather than by buying the cocoons and attending to all the details of egg production themselves, the buyers avoid two difficulties. The first is that of transporting fresh cocoons to any distance without injuring the vigor of the moth, and the second that of obtaining the laborers necessary during the short period occupied by the coupling of the moths and placing them in cells. In many districts the mills turn out their employés that the egg producers may occupy them at this time. In Susani's establishment in Italy, where seven hundred and fifty employés suffice for the period of microscopical examinations, it takes more than three thousand to perform the first stages of the work satisfactorily and with the promptness necessary.

I was informed by a producer in the Cevennes that he sold a good many cells to the silk-raisers of the neighborhood for their own use. Since the establishment of the Pasteur system the number of silk raisers who have acquired the ability of examining the moths producing their eggs has been on the increase, and in certain communes the municipal government has purchased microscopes, which have been placed at the disposition of their citizens for this purpose. This example is one worthy of emulation in any sericultural country, though I regret to say that it is not practiced very generally in France. A similar benefit is derived by Italian silk-raisers through the intervention of the sericultural observatories which were mentioned in my 1887 report.

But while it is not the custom of the French egg producers to carry out the details of the Pasteur system of microscopical selection, I found that in Italy it was universally the habit in responsible houses to examine every moth. To what extent this care is now necessary, the pébrine having so generally disappeared from the sericultural countries of Europe, is a matter upon which a difference of opinion may exist.

There are some cases of infection of the pébrine which takes place very late in the life of the larva, and the whole body, and especially the organs of reproduction, are not immediately affected. The ovaries with their eggs develop soon after the formation of the chrysalis, and if the pébrine has not developed to any great extent in the insect prior to that time the eggs do not become infected. At the same time the disease may advance so that by the time the moth

*That is, those intended for use by the egg merchants themselves for the reproduction of their races.

is examined it will appear highly corpuscular. Under these conditions it will be seen that if all the eggs of pébrinous moths are thrown away there will in many cases be much loss, perhaps unnecessarily. At the same time when the pébrine was so prevalent it was a precaution which was very necessary for the safety of sericultural countries. Egg producers therefore found that a very large proportion of their eggs had to be destroyed as diseased. Some of the less scrupulous ones sold these eggs to other dealers who placed them upon the market. It was found by these latter persons that the eggs which were supposed to be infected gave in many cases as good results as those which were of known purity, and gradually egg producers came to the conclusion that they could make more money by selling the impure eggs under a special "mark" than by selling them for a nominal price to irresponsible dealers. Such success attended these trials that the dealers gradually began to abandon the expensive methods involved in the Pasteur system of selection, and as I found this summer the great majority of those in France have gradually come back to the practice of having those eggs that they intend to sell in bulk laid upon cloth, while those which are intended for sale in cells and those which are intended for their own use for the reproduction of their races are all that are prepared for microscopical selection. The egg-producing districts of France being generally situated, as will be shown further on, in the departments of small production, and consequently in those places where great infection is not probable, such a system may perhaps be used with safety, especially as pébrine is the least feared of all diseases to-day.

As an example of the manner in which work is done by one of the most careful of egg producers in France, who still does not employ the microscopical system of selection to its full extent, I would cite the firm of Ribaud l'Ange and Gorde, of the department of the Basses Alpes, from whom the Department of Agriculture has purchased 100 ounces of eggs for the season of 1890. They produce this year about nine hundred thousand cells and about the same quantity of eggs laid on cloth. All of the eggs which they sell in quantity are laid upon cloth, and to assure themselves of the purity of these eggs for industrial uses they examine, of each lot of cocoons, one hundred chrysalides, and later one hundred fresh moths, putting aside one hundred other moths to be examined when dry. Of each lot of cocoons the eggs from which are to be sold in cells, they examine one hundred chrysalides, and for their own satisfaction one hundred moths from the cells. The buyer, having a moth in each cell, can push the examination as far as he sees fit. Eggs for industrial purposes sold by this house are allowed as much as five per centum of disease and are still considered sufficiently good, but in lots to be used for reproduction each moth must be examined and found pure; consequently such moths must lay in cells.

One fact that I noticed with regret is that many dealers, who acknowledge freely that they do not use the Pasteur system in their general work, still continue to label their egg boxes as though they contained eggs produced after the Pasteur method.

THE SERRELL AUTOMATIC SILK REEL.

Most important of all the items of my letter of instructions was that which directed me to investigate the automatic reeling of silk in France. Two years ago I succeeded with great difficulty in enter-

ing several of the filatures in France and Italy, some of which were equipped with partially automatic machinery. This year I was met with refusal at every hand, and had no means of investigating any establishment but the home filature of Mr. Serrell, at Chabeuil. His system of reeling silk is still, I find upon inquiry, the only automatic system in use anywhere in the world. So far as it is in use at all it is now placed in filatures in France and Italy, aggregating seven hundred basins.

Mr. Serrell began his experiments in New York soon after the Centennial Exhibition. He understood little of the industry of reeling silk or of the details into which it would be necessary for him to go to thoroughly understand it. His idea was that all that was necessary was a machine for automatically keeping the size of the thread as constant as possible. In 1882, after having expended much money and time upon his experiments, and having in the mean time gone to France, he succeeded in producing machinery which accomplished this result with a certain degree of nicety. These machines were set up in the Department of the Drôme, at Chabeuil. They were similar to the machines which were worked in this Department two years ago, and which have already been reported upon. As has been stated, the magazines were still filled by hand, and the operation being an expensive one made the machine lack the requisite economy. By the time he had these machines in operation in a large mill he found that he had begun at the wrong end of the industry, and that instead of inventing machinery which skilled reelers should put into operation, he should first have made himself a skilled reeler, in order that he might better appreciate the delicacies and difficulties of the task which he had undertaken. Further study showed him that there was need of much improvement in the processes destined to prepare the cocoon for reeling, a portion of the industry he had ignored at first. With this end in view he perfected, with the coöperation of Mr. Fougerol, of the Department of the Ardèche, a brushing machine, which has given excellent satisfaction. This was followed by the invention of a cooking machine, which has been placed in most of the filatures affiliated with him. But as is well known, the operations of cooking and brushing the cocoons are not all that are necessary to prepare them for the reeler, and if the whole preparatory system were to be made automatic they should be cleansed by some process still to be discovered.

The delicacy and precision necessary in this operation made it seem well nigh impossible that it could be accomplished by mechanical means. But, notwithstanding the difficulties which beset the invention of such apparatus, it was ultimately accomplished, and as I stated in my report of 1887, a suitable machine for the cleansing of cocoons was perfected and put in operation. This apparatus (a cooker, a brusher, and a cleanser)* constitutes the automatic preparatory machine now in use in the Serrell filatures in France and Italy. The part of the operations which they cover did not, as I have said, enter into Mr. Serrell's original calculations, and at the same time the results attained with them are far better than were anticipated when he expected to make a machine which would simply *reel* silk automatically. It is unnecessary to describe at length how step by step the operation of preparing the cocoons for the reeler has been improved, until now a woman reeling four ends can produce 750

* All of this preparatory machinery is in use in Washington.

grams (about $1\frac{1}{2}$ pounds) of silk per day of twelve hours. This is three times as much as she used to produce when she prepared her own cocoons and reeled them in the old way. But as she now has other operatives to assist her in the preparatory operations the result is really not three times as good as before, though, as Mr. Serrell informs me, the production of silk per diem in his mill is rather better than twice as great per operative as it was before his new machine was put in place.

There have been other difficulties to cope with beside those relating to the perfection of mechanical details. One of the most important and less easily surmountable of these is the conservatism existing among the French manufacturers with whom any inventor must necessarily co-operate. So even after all three of the preparatory operations of reeling silk had been placed upon a mechanical basis, Mr. Serrell found it was necessary to put them into the mills one by one, first teaching the operatives to cook with his apparatus, then that they should brush mechanically, and finally after waiting a number of months before introducing other innovations he placed his cleansing machinery side by side with the other inventions. These delays did not occur only in the first mill equipped, but they were repeated in every mill, one after the other, first in France, then in Italy, then in Austrian Tyrol. And it is due to these delays and vexations rather than to the impossibility of the work that he has been led to temporarily abandon the perfecting of a machine which shall be entirely automatic for the reeling of silk properly speaking. In 1887, after having visited his establishments at Chabeuil and some other points, I secured and brought back to Washington drawings of what was then his most improved machine, which had a magazine to be automatically filled with cocoons by currents of water. As has already been stated in another report this apparatus when put in place was not at all satisfactory. It was but an experimental apparatus as I saw it in 1887, but it was the best that was obtainable at the time and it seemed to do very satisfactory work. While I have been working in the United States to overcome the mechanical difficulties which stood in the way of making this apparatus a success and operative, Mr. Serrell has been working on parallel lines and has, in his estimation, overcome some of the similar difficulties if not all of those which presented themselves to him. In the meantime he has so perfected the preparation of the cocoon that it goes to the basin in much better condition than it ever did before, and as I have said, the daily production of the operatives has been more than doubled. The expense of his experiments, the conservatism of the French manufacturer in adopting those inventions which he has already presented for their consideration, and the satisfactory results which have been attained with those adopted, results which run far ahead of anything he had anticipated from the complete success of automatic machinery, have tended to satisfy him with the present condition of affairs, rather than to stimulate him to the further expense and trouble of experiments in the way of perfecting an absolutely automatic machine. Mr. Serrell, although an American, is now domiciled in France and is working for the European trade and not with an eye to the immediate introduction of his apparatus into the United States, where the industry of reeling silk is, in his estimation, smothered by unjust tariff discrimination. He is therefore carrying the improvement of his machine to the point necessary for the market which he proposes to supply and where the need of an abso-

lutely automatic machine is not so great as it is in the United States. It resulted from these causes that I found at Chabeuil that the home mill was running with only the same preparatory apparatus as the outside mills and that the automatic reels, so far as they had been perfected, had been taken down and stored away for examination at some time when more attention could be given them.

In addition to this the mill at Chabeuil had been leased to the company which operates several of the other factories of his system and they objected to any further experiments being tried upon their reels. On account of this stoppage of experimental work in the large mill, the American owners of Mr. Serrell's patents (who have incorporated themselves as the Serrell Automatic Silk Reeling Company, Limited, of London) have constructed a small filature of thirty basins, near the larger one, which will be used in continuing experiments with different methods of reeling in connection with the preparatory machinery, and later, in all probability, with automatic reels.

A silk filature of one hundred basins of four threads each, using the Serrell preparatory machinery, employs the following producing operatives:

One reeler to each basin	100
One brusher to each five basins	20
One cooker to each five brushers or each twenty-five basins	4
Total producing operatives	124

It is estimated that the perfect operation in such a mill of one hundred automatic basins constructed on the plan which I am now following in Washington would employ:

One reeler at each five basins	20
One feeder at each five basins	20
One brusher at each five basins	20
One cooker at each twenty-five basins	4
Total producing operatives	64

There are also the forewomen, helpers, and sorting force, which probably would not differ in the two systems.

This is a saving of sixty operatives for one hundred basins producing 150 pounds of silk per diem, or a saving of four operatives for each 10 pounds of silk produced. At 50 cents per day this would be 20 cents per pound; at 75 cents per day, 30 cents per pound, and at $1 per day, 40 cents per pound.

It must be understood that these estimates are founded on our present experience with these reels and that they have not been submitted to the test of extended operation.

It will be deduced from the remarks which precede that nothing that I have learned in Europe about automatic machinery for reeling silk from the cocoon will enable me to improve that which we have in the United States. On the contrary, so far as is indicated by the information that I have been able to gather, the machines which have been constructed in the Department are more satisfactorily operative than those which have been constructed in France.

The fact which has struck me most forcibly is our need for expert labor even with automatic machinery. The operative need not be so skilled, but the foreman and director of the filature need far more skill than has ever been required in the past. Not that the skill was

not needed in the director before, but the manufacturers were in the habit of plunging ahead in the darkness without really knowing what their requirements were, and men who were really unfit for the work in hand have been placed at the head of large establishments. If we can decide the great question of silk culture in the United States affirmatively a matter of utmost importance to us will be such a modification of the alien labor law as will permit the introduction into the United States of experts who may act as foremen for our great mills.

NOTES ON SERICULTURE IN FRANCE, ITALY, AND HUNGARY.

Silk production in France.—Any extensive study of the production of silk in countries outside of the United States would be out of place in this report. But for the sake of drawing comparisons with a country in which silk culture is an established fact, and showing how those conditions might be applied to the United States, I venture to submit a few remarks upon a recent sericultural crop in France, and to draw certain conclusions therefrom.

A study of the statistics of silk production of France for 1888 shows that there were produced about 21,120,000 pounds of fresh cocoons. There were in operation two hundred and eleven silk filatures, having a capacity of 10,314 basins. The bulk of the crop was produced in four departments, and an examination of the list of filature patents shows that the mass of the filatures are in these departments also. The following table shows the percentages:

	Crop.	Filature capacity.
	Per cent.	*Per cent.*
Gard	28	44.6
Ardèche	22.8	22.34
Drôme	17.4	13
Vaucluse	15.3	7.4
Other departments	16.5	12.6

It will be observed with what regularity the percentages of filature capacity follow the productiveness in cocoons, the Gard only showing a greater centralization of the mills.

On the other hand the great cocoon producing departments do not produce large quantities of eggs. Of these there were produced in 1888, 903,374 standard ounces, 677,138 pounds of cocoons being consumed in their production, or an average of about two-thirds of a pound of cocoons per ounce of eggs. The following are the leading egg-producing departments, with their percentages of the total French crop of eggs and of cocoons:

	Eggs.	Cocoons.
	Per cent.	*Per cent.*
Var	72.9	4.6
Basses Alpes	14.4	1.7
Corsica	5.9	0.3
Oriental Pyrenees	2.8	0.2
Gard	1.9	28.0
Other departments	2.1	....

This shows that the Gard is the only department of large culture which produces enough eggs to be scheduled, and that it produces less than 2 per cent. of the total. On the other hand, the Var produces only twice as many cocoons as are actually required for her egg production, the Basses Alpes four times, Corsica less than twice, and the Oriental Pyrenees but twice as many as are thus required. As only the best cocoons of the crop are used in reproduction, it is safe to say that all the suitable cocoons of these four departments are used in the production of eggs.

In 1888 there were put in incubation in France 275,224 ounces of eggs, and the production of cocoons per ounce was about 76 pounds. In the departments of large culture the production per ounce was, approximately—

	Pounds.
Gard	82
Ardéche	65
Drôme	68
Vaucluse	84
Average	73

While in the departments producing eggs we find a much better outcome:

	Pounds.
Var	97
Basses Alpes	96
Corsica	108
Oriental Pyrenees	115
Average	97

The production of cocoons per ounce, or, as it is called, the *rendition*, is a very correct indication of the general health of the worms in the department, and we see from what precedes that the eggs are produced in departments of small culture and large rendition.

It can not be that the smaller quantity raised by each person leads to this better result in the egg departments, for the average in each class was almost precisely the same—about 2 ounces. It is due more to the small number of silk-raisers in a locality, and perhaps to the fact that persons who are in the habit of raising for reproduction use more care than those who raise for the filature.

In previous reports I stated that 2½ per cent. of the crop of a country were required for the purpose of reproduction every year. But in 1888 the results had so improved that less than 1 per cent. of the crop would have been necessary to produce as many eggs as were incubated in the spring. France, however, is becoming a large egg producer for exportation, especially to the Levant, her production in 1888 having been double that of 1886.

The Italian crop.—In 1888 77 per cent. of the Italian cocoon crop was raised in the districts of Piedmont, Lombardy, and Venetia, which occupy the northern portion of the kingdom. The crop of that year amounted to 96,500,000 pounds, which is slightly above the average for the nine years ending at that time (86,000,000 pounds). The crop of 1889 has been almost a complete failure, each of the three great provinces suffering severely. In Piedmont but one-half of the average crop was raised, in Lombardy but one-twentieth, and in Venetia but one-ninth, while in the whole kingdom there was a production of but 24,000,000 pounds, or less than one-third of the annual average. France did not suffer so heavily, for while the production

of 1888 was, as has been said, about 17,000,000 pounds for the four great departments, in 1889 it fell to about 13,000,000 pounds, or a loss of one-quarter in the total crop. It should be added that there was a material reduction in the amount of eggs put in incubation in France in 1889 as compared with 1888, which would further contribute to reduce this loss, the average rendition for the four great silk departments in France in 1888 being 74 pounds, while in 1889 it was 64.7 pounds. In Italy the average rendition for 1888 was 60 pounds. The official Italian figures for 1889 have not yet been published. In Austro-Hungary the production did not diminish in 1889, but rather increased. The cause of the serious falling off in the crops of Italy and France was due to bad weather and to the diseases resulting therefrom. The diseases are not those which are inherent in the worms or due to bad eggs, as was the case in those countries twenty years ago. Those diseases, the pébrine and its associated ones, have practically been blotted out by the more careful methods which are used in the production of eggs, and European countries are now liable to be visited only by those produced, as they were this year, by bad weather.

Silk culture in Hungary.—The first effort made to establish silk culture in Hungary was at the end of the seventeenth century, while the first filature for reeling the cocoons was erected about the middle of the eighteenth by the Hungarian Government, which held a monopoly of this industry until 1788. After this date the interest in the work declined, was stimulated by royal influences about 1840, and disappeared entirely during the revolutionary period of 1848. In 1872 the government began to take an interest in the matter again, and organized an inspectorate which was destined to supervise the industry and purchase cocoons. From 1872 to 1879 but 5,500 pounds of cocoons were produced in the kingdom. The following year the inspectorate was reorganized and since that time has been actively occupied in spreading the culture of silk throughout Hungary. During the seven years ending with 1886 the government advanced almost $640,000 for the general expenses of the inspectorate, all but about $90,000 of which has from time to time been restored to the public treasury. It is estimated that during this period the revenues of the poor classes have been increased, through the introduction of this industry, to the amount of $840,000. The Hungarian Government now operates two filatures having together about two hundred and sixty basins. The inspector purchases all the cocoons produced in the kingdom, and as many as are needed are reeled in the government establishments, while the rest are sold in Goritzia or Milan. During the past century a law was passed compelling municipal governments to plant mulberry trees along the highways, and there resulted a very considerable supply of these trees. Silk-raisers are allowed to use the leaves from these trees gratuitously and are furnished with silk-worm eggs which are produced by the inspector. There were distributed in 1889 25,000 ounces of eggs thus produced and about 5,000 ounces of eggs purchased in France and Italy with a view of introducing new varieties into the country. The silk-raisers are indirectly charged for these leaves and eggs by the inferior price which the government pays them for their cocoons. Thus in 1889 the market value of cocoons in the province of Goritzia was about 32 cents per pound, but the Hungarian Government paid silk-raisers but 20 cents.

On the other hand, where silk was raised on shares in Goritzia,

the land-owner furnishing the eggs and leaves as does the Hungarian Government, the peasant received but one-half of the market value, or about 16 cents, which is 4 cents less per pound than was paid in Hungary. The inspectorate derives great benefit from this difference in price when the cocoons are presented at the filature for sale, getting them as has been stated more than 35 per cent. below the market price. What it gives in compensation for this lower price costs the filature nothing on the one hand and very little on the other, for the expense of caring for the mulberry trees falls upon the municipalities and the cost of the eggs, produced as they are in large quantities, certainly would not cost the government more than $1.20 per ounce or about 2 cents per pound of cocoons produced. So that even with this expense the government gets the cocoons for about 10 cents less than the market price. As a result the profits of the government filatures during the seven years ending with 1886 were more than $50,000. The growth of silk culture in Hungary during the period of ten years ending 1889 has been enormous. In 1880 silk was raised by 1,059 families living in 71 towns;* in 1889 by 50,591 families living in 1,639 towns. The production of cocoons, which in 1880 amounted to but 22,288 pounds, in 1889 reached 1,790,683 pounds. In 1880 silk-raisers received for their crop about $5,000; in 1889 it had increased to more than $360,000. In a recent report made by the inspector-in-chief, from which the greater part of these figures are derived, we find that the same conclusions have been reached in Hungary as in the United States, that is to say, that the industry is one which must be carried on on a small scale by members of the family and the moment that it becomes necessary to hire outside labor the work ceases to be profitable. The inspector urges the importance of vigorously prosecuting the planting of mulberry trees as the *sine qua non* of success.

THE WORLD'S PRODUCTION OF REELED SILK.

Some interesting deductions in relation to the silk trade of this country may be drawn from the following tables, which show the countries in which the reeled silk of the world is produced and also the total production for the years 1884 to 1888, inclusive, as well as the amount of silk imported into the United States during the same period.

	Pounds.
Western Europe:	
France	1,755,600
Italy	7,845,200
Spain	182,600
Austro-Hungary	675,400
Total	10,458,800
Levant:	
Anatolie	374,000
Salonica, Volo, Adrianople	264,000
Syria	508,200
Greece	39,600
Caucasia	110,000
Total	1,295,800

* It will be seen how nearly these 1880 figures correspond with our own of 1889.

	Pounds.
Extreme Orient:	
China, exported from Shanghai	4,963,200
China, exported from Canton	1,529,000
Japan, exported from Yokohama	5,280,000
India, exported from Calcutta	2,224,200
Total	13,996,400
Grand total	25,751,000

Years.	Total production.	Imported into the United States.
	Pounds.	*Pounds.*
1884	21,837,200	3,222,546
1885	20,497,400	3,424,076
1886	23,790,600	4,754,626
1887	26,732,200	4,599,574
1888	25,751,000	5,173,840
Average	23,721,720	....

To these figures may be added the remark that the production of raw silk is increasing in western Europe while in the Levant it is on the decrease. With regard to the production of silk in Asia, that is to say in Japan, China, and India, we have no statistics of any reliability. The only items mentioned in the accompanying tables are the exportations from those countries to Europe and America. Therefore the total of silk given is the total amount consumed in Europe and the United States. It will be seen that in 1888 we imported one-fifth of the entire consumption of the western world, and that our importations are rapidly increasing. For the fiscal year ending June 30, 1889, the importation into the United States amounted to 5,329,648 pounds.

The reports of the Bureau of Statistics of the Treasury Department do not show the origin of this raw silk. It may be found, however, in the statistics of the American Silk Association, of New York, which represents the buyers of silk in the United States. Their figures show that a little more than one-quarter comes from Europe, slightly over one-half from Japan, and the balance from China. This ratio has been essentially true since 1884. While one-half of our reeled silk comes from Japan, it is also true that we take half of the reeled silk exported from that country. The growth of this trade has been very rapid, only 108 bales having been shipped to the United States in 1875-'76 as against 5,376 in 1880-'81, 15,034 in 1885-'86, and 20,960 in 1887-'88.

REPORT ON THE CHEMICAL ANALYSES OF OSAGE ORANGE.

SIR: I herewith submit a report of the partial investigation of the value of the *Maclura aurantiaca* (Osage orange) leaves as silk-worm food.

Respectfully,

E. A. V. SCHWEINITZ.

Mr. PHILIP WALKER,
Chief of Silk Section.

In 1853 and 1865 Monsieur Eugène Peligot presented to certain French scientific societies the results of some chemical and physiological investigations of the food and life of the silk-worm. The food examined was the mulberry. Dr. O. Kellner,* at the University of Tokio, Japan, has also conducted a series of experiments as to the value of the mulberry leaf as food for the silk-worm.

A similar series of investigations has been begun by the Department with the Osage orange leaves as food and the Cevennes race of silk-worms.

The experiments were begun after the worms had passed through the first molt. At this time several different lots were selected and weighed, a weighed quantity dried and ignited to determine moisture and ash, and the remaining lots carefully watched during the different stages of growth. The leaves fed to the worms daily were carefully weighed, and the same quantity placed by the side of the tray on which the worms were fed and weighed again after twenty-four hours, in order to determine the loss in weight by spontaneous evaporation. The leaves used for analysis were in this way approximately under the same conditions as the food of the worms. At the end of each molt the residue, that is, the portion of the food left unconsumed by the worms, and the excrement of the worms themselves was weighed and the products thus obtained analyzed. As several lots of worms were selected at the beginning of the experiment it was possible to make an ultimate analysis of the worms and still leave those that had been under the same conditions for further investigation. The time from the first molt to the time for spinning was from May 5 to May 25. Table 1 gives the weight of ten worms calculated, and the leaves, residue, and excrement for each stage, the corresponding percentages of moisture and ash, and the increase in the weight of the worm during each stage. We may mention here that during the last stage of the life of the worm a number became diseased and died, so that the weights of the latter products had to be approximately calculated.

Table 2 gives the ultimate analyses of leaves and products. The high percentage of nitrogen in the food is to be noted as well as the fact that this is in larger amount in the young leaves which were fed during the first stage of the worm's life than later. The lower percentage in the residue shows that the tender portion of the leaf is the richest in nitrogen, and it is upon that which the worm principally feeds. The high percentage of nitrogen means a correspondingly large proportion of albuminoids, a most important constituent of the silk-worm's food.

The ash was in all cases determined by ignition at a low heat in a muffle. The results are shown in Tables 2 and 5. The analyses of this product were conducted according to the ordinary quantitive methods, and the results obtained are calculated upon the basis of an ash free from carbon and carbonic acid. The figures especially to be noted here are the high percentages of phosphoric acid and potash in the food, the very small amount of these in the excrement and the large proportion found in the ash of the worms. The worm selects and assimilates especially phosphoric acid, potash, and magnesia, and excrete silica, lime, iron oxide, and soda.

A comparison of the analyses with those of the French chemist (Table 5) and Kellner (Table 6) shows that the phosphoric acid and potash and magnesia are the essential mineral elements for both mulberry and Osage orange and very necessary for the growth and life of the worm. From Table 2 we may note further that the phosphoric acid is in excess in the young leaf while in the more advanced stage of the growth the potash predominates.

While it is not fair or possible to draw positive conclusions from a single experiment it may be said in general, in so far as it is possible to compare the results we have obtained with those of M. Peligot in 1853, and Dr. Kellner in 1883, that the Osage orange leaves are fully as valuable as those of the mulberry, so far as the chemical constituents are concerned, as a silk-worm food.

In addition to this work it was also the intention to examine chemically the character of the Osage orange leaves from the time of budding till the fall. The feeding analyses show the change in growth of the leaf from May 2 to the 25th. Samples were also collected during June, July, and August, in which ash and moisture determinations were made, but which have not been further examined as yet.

---

* Die landwirthschaftlichen Versuchs-Stationen, Bd. XXX, p. 59.

Samples of the Osage orange leaves grown in Kansas, as well as of the mulberry from the Department grounds and the leaves from the Osage orange tree, have been collected. It is proposed to make further examination of these samples, especially a comparison with the mulberry leaf as grown here, and to give careful study to the proximate constituents of the leaves, residues, and products, the percentage composition of which will be found in Table 4.

TABLE. I—*Experiments in feeding silk-worms with Osage orange leaves, by E. A v. Schweinitz in* 1889.

WEIGHT OF FOOD GIVEN.

Date.	Fresh leaves fed.	Weight of leaves dried— In air.	Weight of leaves dried— Absolutely.	Loss of moisture. Spontaneous drying.	Loss of moisture. Total.	Ash in dry leaves.
1889.	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*
May 2	2.900	1.100	0.654	62.07	77.80	9.61
3	5.000	1.636	1.116	67.28	77.68	10.13
4,5	12.000	2.860	2.074	76.16	82.72	....
6	9.000	2.820	1.434	79.77	84.09	....
8	14.000	5.010	3.429	64.36	65.51	11.09
9	25.000	9.260	4.990	62.56	80.05	12.84
10	27.000	11.700	5.112	56.66	81.07	....
11,12	33.430	11.200	5.832	72.00	82.56	10.88
13	51.570	26.980	9.360	47.68	81.85	10.50
14	65.000	32.830	23.200	49.34	66.27	10.25
15	80.000	45.100	16.392	43.75	79.51	10.52
16	90.000	54.680	21.160	39.24	76.49	....
17	110.000	60.700	24.260	44.81	77.70	9.85
19	110.000	63.570	25.630	41.83	76.95	9.45
20	140.000	109.750	27.810	21.60	80.14	10.09
21	240.000	150.750	52.790	33.44	78.34	....
22	300.000	244.500	72.780	18.50	75.74	....
23	300.000	201.500	62.730	32.83	79.09	9.63
24	150.000	91.500	32.490	39.00	78.34	9.14
25	300.000	112.500	72.120	62.50	75.96	11.61

WEIGHT OF WORMS, RESIDUE, AND EXCREMENT.

	Taken after first molt.	Taken after second molt.	Taken after third molt.	Taken after fourth molt.	Taken at spinning.
Weight of one hundred worms:					
Fresh ....grams..	0.765	3.450	17.395	81.809	345.300
Dry ....do....	0.1091	0.460	1.898	13.741	45.822
Per cent. of ash	9.10	13.81	17.59	12.42	10.38
Per cent. of moisture	....	86.67	89.04	84.39	86.73
Weight of residue:					
Air dried..........grams..	....	4.932	14.370	69.000	94.500
Absolutely dry.......do....	....	4.275	11.389	48.300	82.760
Per cent. of ash	....	10.47	10.36	10.02	8.45
Per cent. of moisture	....	13.33	20.75	30.00	12.43
Weight of excrement:					
Air dried ....grams..	....	0.833	3.405	26.200	68.000
Absolutely dry.......do....	....	0.615	2.852	20.714	60.670
Per cent. of ash	....	11.51	12.47	12.16	10.75
Per cent. of moisture	....	20.00	15.96	20.94	10.79

TABLE 2.—*Ultimate composition of Osage orange leaves, etc.*

	Leaves.				Residue.			Excrement.			Worms.			
	First to second molt.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second molt.	Third molt.	Fourth molt.	Spinning.
Carbon	42.99	41.94	47.18	47.57	47.07	44.14	45.92	40.67	39.45	45.95	.....	42.87	42.21	48.93
Hydrogen	6.00	9.24	5.84	6.02	7.74	6.48	7.59	5.75	5.13	5.83	.....	6.38	6.79	9.31
Nitrogen	5.43	5.01	4.22	3.02	4.70	3.86	3.25	3.44	3.08	2.58	14.00	12.98	10.92	9.97
Oxygen	35.71	31.90	32.24	33.33	30.13	35.50	34.79	37.67	40.18	34.89	.....	20.18	27.66	21.41
Ash	9.87	11.60	10.52	10.06	10.36	10.02	8.45	12.47	12.16	10.75	13.81	17.59	12.42	10.38

TABLE 3.—*Composition of the ash of Osage orange leaves, etc.*

	Leaves.				Residue.			Excrement.			Worms at spinning time.
	First to second molt.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	
Silicic acid	8.75	10.10	7.86	7.59	12.10	7.81	6.19	27.31	13.61	14.04	4.22
Sulphuric anhydride	2.76	4.11	3.14	4.46	3.87	15.70	6.02	3.47	2.87	2.96	1.66
Phosphoric acid	23.45	15.12	4.94	15.52	18.86	8.65	9.74	2.06	9.30	5.75	27.45
Chlorine	trace.	tracc.	trace.	trace.	......	......	......	trace.	trace.	trace.	trace.
Lime	20.73	17.10	21.01	21.71	19.64	26.79	48.00	28.17	30.70	37.19	14.58
Magnesia	20.70	6.78	7.29	7.57	8.20	7.20	7.09	6.07	7.05	7.83	12.79
Soda	2.70	2.83	2.06	2.11	3.03	1.85	4.37	3.00	5.28	2.91	1.19
Potash	15.94	30.28	37.96	38.50	27.97	28.91	16.94	23.09	23.91	19.65	35.15
Iron oxide	4.93	14.37	5.33	4.02	5.71	3.07	4.33	6.27	7.61	9.87	2.27
Boracic acid	trace.	trace.	trace.	trace.	......	......	......	......	......	......	......

TABLE 4.—*Proximate composition of Osage orange leaves, etc.*

	Leaves.				Residue.			Excrement.		
	First to second molt.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Second to third molt.	Third to fourth molt.	Fourth to spinning.
Petroleum ether extract	9.86	9.51	12.24	12.26	9.67	8.21	9.53	10.88	8.10	7.97
Ether extract	9.25	9.01	10.01	9.16	9.93	8.21	7.30	9.59	7.75	7.48
Albuminoids	33.93	31.31	26.40	18.87	29.37	24.12	20.31	21.52	19.25	16.12
Carbohydrates, starch, etc., by difference	27.26	30.36	19.68	20.33	31.83	20.05	21.11	19.69	10.25	22.67
Ash	9.87	11.60	10.52	10.06	10.36	10.02	8.45	12.47	12.16	10.75
Crude fiber	8.83	8.21	21.02	28.29	8.84	29.39	33.30	25.85	42.49	35.01
Ninety-five per cent. alcohol extract	26.69	28.63	18.27	19.29	30.00	18.61	20.16	18.22	9.19	18.69

TABLE 5.—*Analyses of the mulberry leaf by M. Peligot (France).*

ULTIMATE COMPOSITION.

	Leaves and residue.	Worms.	Excrement.
Carbon	43.73	48.10	42.00
Hydrogen	5.91	7.00	5.75
Nitrogen	3.32	9.60	2.31
Oxygen	35.44	26.30	36.14
Ash	11.60	9.00	13.80

COMPOSITION OF THE ASH.

Silica	21.62	4.35	24.30
Phosphoric acid	12.60	32.40	9.26
Sulphuric anhydride	1.90	2.12	....
Chlorine	.98	1.22	1.46
Iron oxide	.73	trace.	.85
Lime	32.18	9.27	35.38
Magnesia	7.12	10.39	7.92
Potash	22.60	40.22	20.73

TABLE 6.—*Analyses of the mulberry leaf by Dr. O. Kellner. (Japan.)*

PROXIMATE COMPOSITION OF LEAVES, ETC.

	Leaves.				Residue.		Excrement.	
	First to second molt.	Second to third molt.	Third to fourth molt.	Fourth to spinning.	Third to fourth molt.	Fourth to spinning.	Third to fourth molt.	Fourth to spinning.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Albuminoids	29.83	29.00	27.84	25.00	28.99	24.94	17.33	16.03
Crude fat	5.51	4.88	4.14	3.25	3.53	3.19	2.16	2.16
Crude fiber	10.35	11.34	11.57	10.44	12.90	11.35	14.63	13.91
Nitrogen free extract, carbohydrates	46.89	46.78	47.51	52.47	44.95	51.39	53.34	55.72
Ash	7.42	8.00	8.94	8.84	9.63	9.13	10.05	10.87

COMPOSITION OF THE ASH.

	Leaves.		Residue.		Excrement.	
	Third to fourth molt.	Fourth molt to spinning.	Third to fourth molt.	Fourth molt to spinning.	Third to fourth molt.	Fourth molt to spinning.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Silicic acid	18.03	25.03	19.38	22.06	19.09	30.32
Sulphuric anhydride	2.95	2.05	2.97	1.92	3.10	2.72
Phosphoric acid	8.28	5.96	5.84	6.22	7.06	4.84
Chlorine	0.39	0.69	0.38	0.71	0.39	0.96
Lime	33.48	30.39	32.22	29.25	35.55	30.01
Magnesia	8.00	10.64	8.02	9.20	6.55	9.56
Soda	1.24	1.82	1.40	2.84	1.32	1.65
Potash	26.43	21.95	28.70	26.33	24.42	18.39
Iron oxide	1.72	1.43	1.87	1.31	1.43	1.49

REPORT OF THE CHIEF OF THE SEED DIVISION.

SIR: I have the honor to submit to you the annual report on the operations of the Seed Division for the past year, together with some suggestions which seem to me pertinent if the work of this division is to attain the highest degree of usefulness.

During the past year the detailed work of this division has differed little from that of previous years, and consisted largely in receiving, examining and testing, putting up in suitable packages for distribution, and distributing throughout this country, and in some cases to foreign countries, the seeds purchased under the provisions of the act of Congress appropriating money for "the purchase and distribution of seeds."

Appended to this report is a tabulated statement of kinds and quantity of seed issued from the Seed Division for the fiscal year ending June 30, 1889. It deserves attentive perusal as it fairly represents a year's work of this division, and is so arranged that it indicates the various channels through which the distribution of seeds takes place as well as the grand total of such distribution. The aggregate of packages distributed exceeded 4,850,000, and included 6,630 bushels of cereal and other field seeds, 48,300 pounds of vegetable seeds, and 600 pounds of flower seeds. Cloth bags and paper packets in which the seeds were put up were mostly made in this division, and the manuscript was also prepared here for the printed labels, and in many instances for the directions for the cultivation of plants which were new to portions of the country where they were distributed.

I include in this report condensed reports from correspondents in reference to seeds distributed by this division, arranged alphabetically according to States. In this connection it is proper that I should call attention to the fact that while many correspondents endeavor to comply with the regulation requiring a report from each person to whom seeds are distributed as to the results obtained with them, and although in this way many valuable reports reach us, yet by comparison with the extent of the distribution the number of reports received is comparatively insignificant. Indeed, it is not too much to say that a large proportion of the recipients of seeds, dealt out with such a liberal hand, make no return whatever, apparently regarding the requirement imposed upon them in accepting this favor as a dead letter.

A glance at the tabulated statement already referred to will show the proportion of seeds distributed through the statistical agents and correspondents to miscellaneous applicants, to experiment stations

and agricultural colleges, and through agricultural societies. So far as the statistical agents and correspondents are concerned the distribution to them is but a partial return for the valuable services which they render gratuitously to the Department, and such distribution must therefore be fully maintained if not increased. The distribution to experiment stations and agricultural colleges has so far brought about excellent results. The care exercised by these institutions in the planting and cultivation, in the notes and observations systematically recorded, as well as the familiarity of the station directors and superintendents of college farms with the soil and climatology of their respective States, all tend to make their reports of extreme value to this division in carrying out systematically and scientifically the praiseworthy ends for which it was established. An increase in this channel of distribution is extremely desirable, if not so much perhaps in number of packages at least in the quantities distributed.

There is no doubt whatever of the good results accomplished heretofore through the Seed Division, and though many instances can no doubt be pointed out in which results have seemed to be incommensurate, as when recipients of seeds have been disposed to regard this division simply as an eleemosynary institution, the proper course is unquestionably not to ignore the good already done, but to adopt methods calculated to insure the most practical results, and then on this line to prosecute the work with the utmost energy and liberality.

The addition to the staff of this division of a special agent who personally visits different sections of the country inspecting, as far as possible, the product of the seeds offered to the Department and looking up such as seem to possess "specially desirable characteristics" has already proved to be a wise move, and there can be no question of the valuable aid thus rendered to the division in effecting the purchase of suitable seeds.

I can not close this brief report without calling your attention in the strongest manner possible to the grave inconveniences to which the force under my control is compelled to submit owing to the totally inadequate room devoted to the use of this division. That such a state of things as exists in this respect necessarily interferes gravely with the efficient performance of the division goes without saying. The prompt dispatch of business is essentially important in connection with seed distribution, and I am much hampered and embarrassed by this want of room.

I subjoin the "condensed reports from correspondents," already referred to, and append to the present report the tabulated statement showing the kinds and quantities of seed distributed and the channels of such distribution.

I have the honor to remain, sir, very respectfully yours,

A. T. LONGLEY,
Chief of Seed Division.

HON. J. M. RUSK,
Secretary of Agriculture.

CONDENSED REPORTS FROM CORRESPONDENTS.

ALABAMA.

Corn.—The Piasa King is reported as being much earlier than other varieties tested and was very prolific. The Champion White Pearl still holds its position as a great favorite; it is a valuable variety.

Cotton.—The Wimberly's Improved made from twenty-eight to thirty bolls to a stalk.

Vegetables.—The seed received from the Department have been very successful, and have proved to be very well selected for this soil and climate; among those which have given special satisfaction are to be mentioned the Alaska pea, Perry's Hybrid sweet corn, Eclipse beet, Early Mohawk bean, and the Fulton Market tomato.

ARKANSAS.

Corn.—The Champion White Pearl has proved to be extra early, with a very large and fine grain, yielding 50 bushels to the acre, and perfectly hardy. The White Giant Normandy grew luxuriantly, yielding from 50 to 60 bushels per acre; it was from ten to fifteen days earlier than other varieties tested.

Cotton.—Wimberly's Improved produced 30 per cent. more than the common varieties. The King's Improved was a very good variety, with small seed and fine long lint.

Clover.—Alfalfa is a grand success in Arkansas, as it withstands the long droughts.

Sorghum.—The Early Orange has been grown with good results for the past two years. It matures early and can be planted closer than other canes. It will yield 150 gallons of beautiful sirup to the acre.

Wheat.—All wheat was injured in this State by the Chinch Bug, but the Fulcaster did much the best of any of the varieties tested. It is doubtless a good variety for this State.

Vegetables.—Gardening here begins in February and March. Long Yellow Six-weeks' beans, Scarlet Globe radish, and Danvers yellow onion produced well and were of fine quality. The pale Dun beans proved strong growers, very prolific, and A No. 1 in quality.

CALIFORNIA.

Corn.—The White Giant Normandy and Champion White Pearl have both done extremely well in this State, and when acclimated will doubtless be valuable. One pound of seed of the White Giant Normandy harvested 380 pounds of sound white corn.

Oats.—Hargett's White made a large yield, matured early, with full heads.

Vegetables.—The Chicago Market was considered the most delicious of six varieties cultivated. Phinney's Early watermelon was hardy, a good shipper, and resisted the great heat of this locality. One weighed 32 pounds. Commodore lettuce was crisp and handsome.

FLORIDA.

Cotton.—Welborn's Pet is a fine variety; it has doubled itself. Cluster Champion bore large pods of beautiful white cotton, and the experience of cotton planters goes to prove that it would pay to cultivate it as well, if not better, than the Sea Island. Truitt's Improved has also given satisfactory results.

Clover.—Alfalfa grows rapidly, seeds heavily with good sound seed, and is well suited to West Florida.

Buckwheat.—The Japanese is reported as having done well.

Forage plants.—The Unknown pea is considered the best fodder plant ever introduced into the South; its growth and production was enormous, and during the two months of drought it never wilted.

Wheat.—An interesting report from Chuluota, Orange County, makes the following statement in regard to Mediterranean Wheat:" From thirty-four kernels sown, harvested 4 pints of clean wheat, of finer and better quality than I ever raised in Pennsylvania. The wheat stooled from four to twelve stalks to the kernel. Rust showed a very little on the blades just before harvesting, which indicated that it should have been sown in October instead of November. On a decomposed shell soil I believe wheat will be a complete success in Florida, if the Australian or California seed could be obtained."

GEORGIA.

Cotton.—The Champion Cluster is a valuable variety; it grew well and began to open one week earlier than other varieties; the bolls were uniformly large and the stalks prolific.

Wheat.—Currell's Prolific made the largest yield of well matured grain ever made in White County.

Sorghum.—The Orange cane came up well, grew rapidly, and is superior in size, yield, and quality of sirup. The Goose Neck is superior in all respects to all other varieties.

Vegetables.—The Champion of England and the Alaska peas are highly commended for earliness and productiveness. The Early Mohawk bean, Danvers onion, and Early Pointed Leaf cabbage were also very successful and gave general satisfaction.

ILLINOIS.

Wheat.—Currell's Prolific has proved a strong, thrifty grower, and resists storms much better than other varieties tested, and is by many considered very much superior in all respects. The Mealy was given a fair trial and found first-class in quality and yield; the grain was plump and of good color. The Good stood the winter very well and was very early in heading; the straw was stiff, the heads well filled, and the quality was extra. The Sibley's New Golden looked green all winter; its straw was very stiff and looked like gold; it is to be highly recommended. The German Emperor is a great tiller, has long straw and nice long heads well filled; it will average more to the acre in bushels than any other kind in this section.

Tobacco.—The White Burley grows well and is a very fine color. Vuelta de Abajo is fine as a smoking variety.

INDIANA.

Corn.—The Champion is well adapted for general cultivation. The Golden Beauty is well worthy of distribution.

Honey plant.—The Chapman was a great success; the bees reveled in it; every flower had five or six at a time on them, both early and late.

Wheat.—Currell's Prolific is reported as having made a splendid yield; it spreads well, is deep rooted, and makes fine heads, some as high as eighty grains per head; it is to be recommended. The Fulcaster is highly spoken of in all respects. The Mealy proved to be a valuable acquisition. The Velvet Chaff also made a good crop. The Improved Rice gave satisfactory results.

IOWA.

Corn.—The Yellow Dent is an excellent variety, yielding well, and is to be recommended.

Clover.—Alfalfa grew luxuriantly; it is well worthy of further trial.

Buckwheat.—The Japanese yielded one-third more than other varieties and was of excellent quality.

Barley.—The Melon was productive and excellent.

Vegetables.—The Olive Shaped radish was crisp and delicious. The Early Red Valentine bean, the Eclipse beet, and the Beauty tomato were all excellent varieties.

KANSAS.

Corn.—The Angel of Midnight is an early variety, is hardy, and yielded well.

Clover.—Alfalfa withstood the drought and proved a valuable forage plant for Kansas.

Sugar beet.—Made a very fine crop, notwithstanding bugs, hot weather, and winds.

Wheat.—Currell's Prolific has made a remarkable yield. The German Emperor yielded 42 bushels per acre, and stands the winter well.

KENTUCKY.

Corn.—The White Giant Normandy is an excellent variety and is noted for earliness, hardiness, and yield. The Hickory King made a fine crop. The Early White Pearl was very early and very excellent in quality.

Vegetables.—The Maud S. peas were excellent in quality and very productive. The Eclipse beet grew to a large size, were early and tender; the finest vegetables raised this season were the result of Department seed.

LOUISIANA.

Cotton.—The Peterkin's Improved proved to be an excellent variety, good staple, with large bolls. Wimberly's Improved was prolific; the bolls were large and the

lint fine; it was eight days earlier than some others planted and cultivated under the same circumstances.

Teosinte.—The Louisiana Sugar Experiment Station reports that this plant has seeded there; one row of 800 yards being very thickly filled with seed.

Vegetables.—The Golden Queen tomatoes grew finely, were of good quality; it is an excellent variety. All Seasons cabbage is a fine variety. The Maltese parsnip were fine and large.

MAINE.

Corn.—The Angel of Midnight yielded well; the ears were long and well filled, with small cob and large kernel.

Oats.—Hargett's White gave very satisfactory results; the berry was plump, the straw stood up well, and yielded largely.

MARYLAND.

Sorghum.—The Early Amber grew finely and produced abundantly; the manufacturer pronounced it the best that ever came to the mill, making clear and sweet sirup; it is also an excellent forage plant.

Wheat.—The Improved Rice grew nicely and stood the winter well; matured five days earlier than any other variety; the grain was of medium size and good in quality, well suited to this soil and climate.

Vegetables.—The Livingston Beauty tomato is all that is claimed for it. The Alaska pea was pronounced as unsurpassed in quality. The Deacon lettuce made a good yield and was of excellent quality.

MICHIGAN.

Corn.—The Angel of Midnight is a very fine milling variety; the Leaming and Pride of the North made each a fine growth and large yield.

Barley.—The Melon is a good variety, yielding from 25 to 30 grains per head.

Grass.—The Festuca Elatior will prove a valuable acquisition, as it roots deep and is a rapid grower.

Wheat.—The Improved Rice was harvested one week earlier than other varieties; yield was at the rate of 32 bushels per acre; the berry was fine and plump, straw tall and strong; many report highly of this variety; 3 pounds of seed yielded 30 pounds. The Mealy and Currell's Prolific were both well adapted to this locality.

MINNESOTA.

Corn.—The Angel of Midnight matured in ninety days from planting; grew to a height of 6½ feet, yielded well, and was a very handsome variety.

Oats.—The New American grew very strong in straw, with large heads of good quality.

Barley.—The Melon was superior to any other raised here; 1 pound of seed yielded 61 pounds of nice white No. 1 barley.

Sorghum.—The Amber, although somewhat injured by early frost, made 46 gallons of sirup from one-fourth of an acre.

Vegetables.—The Rural New Yorker pea did very well and was very early. The Alaska pea was pronounced as unsurpassed in quality. The Valentine beans and Sure Head cabbage are choice varieties.

MISSISSIPPI.

Cotton.—The Champion Cluster did remarkably well.

Honey plant.—The Chapman reached a height of 5½ feet; continued in bloom thirty days; it yielded an abundance of bloom and the bees worked busily on them until the last bloom was gone.

Forage.—The Unknown pea surpassed every cow-pea for vine and yield ever grown here; it was admirably adapted to the South.

MISSOURI.

Corn.—The Champion White Pearl is very early and excellent in yield and quality; it received the first premium at the Gasconade County fair. The Mosby's Prolific was of good quality and large yield.

Oats.—Hargett's White made seven to ten stools to a single grain; the straw stands well and will doubtless be a profitable crop in a little drier season.

Wheat.—Currell's Prolific made an abundant yield and stands the winter well. If upon further test it proves to be a good milling wheat it will become one of the leading varieties. The Fulcaster stands the winter well, makes nice plump grains,

with strong heavy straw. The German Emperor has proved very satisfactory. The Improved Rice stood up well: one-fourth of an acre yielded 150 pounds.

Teosinte.—Experiments with Teosinte seed raised in Florida give the result as differing little from the imported; it germinated and grew as well, yielding about the same amount of forage per acre—about 45 tons of green fodder.

Sorghum.—The Early Amber appeared true to name. If planted early and cut when ripe it will sprout four or six stalks from each one and will make a splendid fall feed. It is rich in saccharine and grains readily. The Late or Yellow Amber is a profitable variety. The Orange cane made 8½ gallons of thick molasses from 60 gallons of juice. The India cane made 6 gallons from 60 gallons of juice. The Orange is best adapted to this section.

Sugar beet.—Was very superior and will be cultivated for cow feed, as they are capital for milch cows and impart color and fragrance to the butter.

Tobacco.—The Yellow Pryor has been one of the most productive and most salable in the market. The Caboni, Fiji, Oronoco, and White Burley are all reported as having done well, the White Burley rather having the preference.

NEBRASKA.

Clover.—The Mammoth, or Red, rooted well and made a good growth. It has proved a valuable variety.

Sorghum.—The Early Orange succeeded well; three-fourths of an acre planted with seed from the Department made 160 gallons of excellent molasses.

Sugar beet.—One and one-half pounds of seed produced 7 tons of nice beets. A sugar-beet factory here would be very profitable.

NEW YORK.

Corn.—The Eight Rowed Canada is an excellent variety for this latitude. The Early Adams was very early and excellent in quality.

Oats.—Hargett's White were very satisfactory in every respect.

Wheat.—The Spring Beardless has proved to be a good variety for this section; although sown late every seed germinated and yielded at the rate of 15 bushels per acre. The Mealy heads were about 3 inches long with 3 or 4 grains to a spikelet, and of good quality. Currell's Prolific is a valuable beardless variety, hardy and vigorous in growth, the berry very hard and flinty; quality was A No. 1.

Sorghum.—The Early Amber made an abundance of fine sirup. One correspondent writes: "Notwithstanding an unfavorable season I harvested from the Early Amber seed at the rate of 21 tons 640 pounds to the acre."

Sugar beet.—Every seed grew, and we made a fine crop of excellent quality from the seed received from the Department.

Grass.—The lawn grass grew well and made fine sod.

Vegetables.—All the seed received from the Department has germinated and given satisfaction both in quality and quantity.

NORTH CAROLINA.

Wheat.—The Bill Dallas has proved to be a profitable crop under good cultivation.

Sorghum.—The Orange cane was planted on one-eighth of an acre and yielded 40 gallons of good sirup.

Tobacco.—The White Stem Orinoco is very early and of quick growth; it is three weeks in advance of native varieties; it stands drought, and has a large leaf.

OHIO.

Corn.—The Champion White Pearl is very hardy, prolific, and early.

Wheat.—Currell's Prolific had a large berry and very strong stiff straw; it is worthy of further cultivation. The Improved Rice was very early, and had a stiff straw. The Mealy was very early; 4 quarts of seed threshed 6 bushels, and weighed over 60 pounds to the bushel.

Sorghum.—The Early Amber ripened evenly and grew to the height of 8 feet. Cows eat it greedily, and given to a sick horse, it acted like a tonic and invigorated its whole system.

OREGON.

Clover.—Alfalfa did well in this locality.

Oats.—Hargett's White has proved a success in Oregon; from one package 41 pounds were harvested, and the grain was much larger than that of the original.

Wheat.—The Mealy and Currell's Prolific proved a success. Sibley's New Golden

yielded at the rate of 50 bushels per acre; the grain was plump, the berry large and bright.

Vegetables.—The yield of the Sure Head cabbage, Scarlet Top radish, Beauty tomato, and the Alaska pea were all very satisfactory.

PENNSYLVANIA.

Wheat.—The Improved Rice yielded well and will prove a reliable and heavy cropper. Currell's Prolific made a good stand; the straw was strong and stood up well. Sibley's New Golden proved a superb variety; largest yield twenty-seven stalks from one seed; the straw was strong and heavy.

Sorghum.—The Early Orange did finely; it grew rapidly and made nice large heads; one-eighth of an acre yielded 16½ gallons of rich sirup.

Vegetables.—The Champion of England and the Alaska peas were very satisfactory in both earliness and productiveness. The Early Mohawk beans, Perry's Hybrid sweet corn, Eclipse beet, and Fulton Market tomato were all of good germinating qualities.

SOUTH CAROLINA.

Corn.—Mosby's Prolific, Champion White Pearl, and Piasa King, were all valuable acquisitions.

Cotton.—Peterkin's Improved, after twenty-five years' experience in testing many varieties, has surpassed all others in yield of lint and in the quality of seed cotton. Wimberly's Improved was noted for its earliness, fruitfulness, and the fineness of its lint.

Sorghum.—The Amber cane is a most desirable forage plant; its early maturity and rich saccharine matter, with its small stalk, make it a very valuable addition to the forage supply of the farm.

TENNESSEE.

Corn.—The White Giant Normandy, after three years' experience, is pronounced one of the greatest acquisitions in the way of an early field corn ever introduced into this latitude; it has the largest grain, of a rich pearl color, and makes the finest quality of meal; its ears are in roasting condition when ordinary field-corn is in silk or tassel.

Cotton.—The Ellsworth suits this soil and climate well.

Wheat.—Martin's Amber made a good crop of clean wheat. The Fulcaster is a very desirable variety and will take the lead in this section. The Good produced good nice grain, entirely satisfactory.

Sorghum.—The Orange cane is an excellent variety and yielded abundantly; it ripened three or four weeks earlier than other varieties.

Forage.—The Unknown pea was very prolific and made an enormous growth of vine.

TEXAS.

Corn.—The White Giant Normandy was quite early and yielded 60 bushels to the acre; it was a perfect success. The Piasa King was planted two weeks later than others, but ripened quite as early, and yielded a slight percentage more than other varieties.

Cotton.—Jones's Improved Prolific made exceedingly fine lint, and was very prolific. Welborn's Pet is an excellent variety. Champion Cluster made large bolls, lint fine and soft, was very prolific.

Oats.—The American Improved made a vigorous growth, and the yield was very good.

Sorghum.—One fifth of an acre planted in Amber cane made 4,600 pounds of stock fodder and 5 bushels of seed. Early Orange cane grew 8 feet, and made 196 gallons of sirup to the acre; it was of fine flavor and could have been cut a second time, but was kept for forage. The Chinese cane grew finely; it reached the height of 12 feet, and an average sirup in quality—246 gallons to the acre. For forage it will surpass any grass or cane of the day, but for sirup the Early Orange is to be preferred. The Red Liberian grew most luxuriantly.

Barley.—The Melon stooled out largely, yielded well, and made good grain.

Forage.—The Unknown pea made a fine yield and luxuriant growth.

VERMONT.

Oats.—Hargett's White can be grown in this locality with profit. The Improved American was very thrifty in growth, the straw tall and coarse.

VIRGINIA.

Corn.—The Piasa King grew marvelously fast and attained a height of 10 feet. Every stalk bore two full ears averaging 10 inches in length; the ears were not only

symmetrical in shape but well filled. It is snow white in color, very tender, juicy, and sweet. The Pride of the North has been a great acquisition; it does well on moderately good land, ripens early, is hardy, quite prolific, with very long grain and extremely small cob. The White Giant Normandy did well, as also did the Hickory King.

Oats.—Hargett's White made a very fine yield. One grain, from actual count, produced one hundred and sixty-five grains. The grain was large, the straw tall and strong.

Wheat.—Currell's Prolific has a large head with a strong stalk which grew about 4 feet and made a stool and twenty heads from one grain. Winter Rice sown at the same time is an excellent variety, about the same height, and branches well. One stool of twenty-five stalks and heads made five hundred and forty-five grains. Will produce 30 or 40 bushels to the acre. The Hindostan headed earlier than other varieties and was not injured by wet weather; it stood erect; the straw was tall and the wheat of good quality.

Tobacco.—The Gooch Broad Leaf germinated well and made a very heavy yield. Leaf was 2½ by 3 feet, quality very fine, the finest texture for red wrappers, fine fiber and small stem. The Theiss is a good cropper; yield one-half pound to the plant; heavy fillers. It is at home in this soil and climate and is a very sweet and high-flavored tobacco and can not fail to bring the highest price in the market for first-class fillers. Szegedina proved to be the earliest of the three varieties tested; the quality was good; it will prove a very valuable crop for Northern States, as it is excellent for chewing in the leaf; of fine flavor and body.

WEST VIRGINIA.

Corn.—One pound of Leaming seed yielded 584 pounds of excellent quality.

Oats.—The Hargett's White was just what this section needed. The grain was plump and fine and the yield very good.

Kinds and quantities of seed issued from the seed division of the Department of Agriculture, under the general appropriation act of Congress, from July 1, 1888, *to June* 30, 1889.

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	County statistical correspondents.	State statistical agents.	Miscellaneous applicants.	Experiment stations and agricultural colleges.	Agricultural societies.	Total.
		Packages.	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
Vegetable	163	2,967,088	175,120	51,946	503,666	3,648	8,756	3,710,224
Flower	144	215,001	20,160	3,720	68,844	....	82	307,807
Honey plant	1	32	....	....	417	173	372	994
Tobacco	18	105,212	66,600	4,781	8,293	337	1,024	186,247
Tree	6	32	....	....	643	....	....	675
Sunflower	1	....	....	....	3,222	....	290	3,512
Pyrethrum	1	....	....	....	9	....	....	9
FIELD SEEDS.								
Wheat	4	541	....	....	2,141	107	148	2,937
Oats	2	2,281	3,524	286	1,317	218	687	8,313
Corn	10	11,546	3,518	438	4,577	365	815	21,259
Barley	1	1,173	50	....	220	36	53	1,532
Buckwheat	1	10	....	....	513	48	116	687
Rye	1	67	....	....	169	25	50	311
Sorghum	39	478	214	178	1,834	734	2,872	6,310
Kaffir corn	2	....	....	....	404	214	496	1,114
Broom corn	1	....	....	....	215	....	....	215
Turnip	10	399,113	109,872	23,580	10,536	732	4,176	548,009
Sugar beet	2	365	196	123	1,436	....	64	2,184
Mangel-wurzel	1	3,430	....	....	1,078	....	77	4,585
Grass	9	10,441	345	216	3,551	213	615	15,381
Clover	7	10,512	....	....	2,457	146	378	13,493
Millet	1	....	....	....	108	....	....	108
Teosinte	1	90	....	683	725	46	158	1,702
Forage plants	6	....	143	84	852	356	1,312	2,747
TEXTILE.								
Cotton	6	4,700	5,328	....	1,438	174	489	12,119
Ramie	1	....	....	....	38	....	....	38
Grand total	......	3,732,112	385,070	56,035	618,693	7,572	23,030	4,852,512

REPORT OF THE DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

SIR: I have the honor to present herewith the report of the Office of Experiment Stations for the year 1889.

It is, of course, impossible within the limits set for this report to do more than indicate some of the striking features of the diversified undertakings of the experiment stations. I trust, however, that the facts given will suffice not only to indicate the scope of the work of this Office and the general character of the experiment station enterprise as a whole, but also to show the value of the work now being done by the stations and the promise of its constantly increasing usefulness.

Respectfully,

W. O. ATWATER,
Director.

HON. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The number and diversity of problems to be solved in the widely separated sections of our country, and the need of linking the stations together, of co-ordinating their efforts, of bringing to them the fruits of accumulated experience, of assisting them in research, and of collating their products and making them available to the public, all evince the wisdom of Congress in providing for a central agency as a branch of this Department to meet the need. It is the duty of this Office to indicate lines of inquiry, furnish such advice and assistance as will best promote the objects for which the agricultural experiment stations are established, and to "compare, edit, and publish such results" of their work as may be deemed necessary.

It is also intended to connect the stations with the several branches of the Department, to bring its workers into relations with those engaged in similar lines of research in the stations, and to make the results of the investigations of the Department more widely useful to the whole country by aiding in their dissemination through the publications of the stations and of this Office, and through such agencies as the farmers' institutes, in which the stations in many sections are actively participating.

The report of this Office for 1889 naturally divides itself into three general sections—the operations of the Office, the work of the experiment stations, and facts regarding the agricultural colleges and farmers' institutes, with which the stations are more or less in-

timately connected. The work of the Office has included correspondence, visiting stations, attendance on farmers' meetings and conventions of college and station officers; the collection of a mailing list; the collection and cataloguing of station and other literature; the collection of statistics and historical and other data regarding the stations, colleges, and farmers' institutes; and the promotion of co-operation among the stations. Besides these things, a most important part of its business has been the publication of a digest of the annual reports of the stations; a record of the current bulletins of the stations and of this Department; the proceedings of the conventions of the Association of American Agricultural Colleges and Experiment Stations, of station horticulturists, and of other station officers; bulletins for farmers and horticulturists; forms for reports of station horticulturists; organization lists of the stations and colleges; and circulars and letters of inquiry and information on topics relating to station work. This part of the report also contains an outline of the proposed work of the Office in 1890, a statement of its needs, and suggestions regarding special lines of inquiry which may profitably be undertaken by the stations in the immediate future.

That part of the report which relates to the operations of the stations contains first of all a number of brief statements which illustrate the usefulness of such work. Then follow general statistics regarding the lines of station work, number of stations and station officers, number of station publications, etc.; and finally some conclusions as to the status, needs, and prospects of the station enterprise. In the third division of the report are given a list of the schools and colleges in the United States having courses in agriculture, with locations and names of chief officers; brief facts relating to the organization of new institutions; and a list of the States in which farmers' institutes are held, with governing boards, and the names and addresses of State officers and other persons to whom application may be made for information about the institutes.

Those who desire to investigate the work of the stations in special lines will note that the bulletins and annual reports of the stations are sent on application to the respective stations. Numerous references to the station publications will be found in this report, either in the text or in foot-notes, and a list of the stations, with the names of directors and addresses, is given on pages 530–531. The publications of this Office intended for general distribution are also sent to those who apply for them. A list and description of these publications may be found on pages 488–491. As the editions are limited, the Office can not undertake to supply full sets of its publications, except in special cases.

OPERATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

WORK OF THE YEAR.

Correspondence.—The correspondence of the Office is already large and rapidly growing. The number of letters received and written during the year is in round numbers four thousand eight hundred.

The visiting of stations, conventions, and farmers' meetings has become an important duty of the Office. Since the last annual report was presented fifteen stations have been visited. Conventions of station workers have also been attended at Knoxville, Tenn., Washington, D. C., and Columbus, Ohio. The director or assistant di-

rector has also attended and addressed farmers' meetings in Kansas, New Jersey, Connecticut, and Virginia; the meetings of the Association for the Promotion of Agricultural Science, and the American Association for the Advancement of Science, at Toronto, Ontario; the Association of Official Agricultural Chemists, at Washington, D. C., and the American Public Health Association, at Brooklyn, N. Y.

Collection of a mailing list.—Persistent effort has been made to obtain and keep up to date an accurate list of the governing boards and working corps of the stations, of the officers and trustees of the agricultural colleges, and of such investigators and periodicals as desire the publications of the Office. Exertions have also been made to collect a large list of practical farmers, in making which the Office has not only taken the names of those who have written for bulletins, amounting to several thousand, but has also made use of lists furnished by the stations of the several States. Since the mailing lists of the stations aggregate about two hundred thousand names, the task of collating, copying, and correcting these lists has been too great to be fully accomplished during the year. A very large mailing list of farmers, moreover, can not be utilized until larger appropriations enable the Office to publish adequate editions of its popular bulletins.

Collection of publications.—The effort to secure a complete collection of station publications for the library of the Office has been steadily pursued. The earlier publications are exceedingly difficult to obtain. A card catalogue has been kept up to date to serve as a basis for a general index of station literature.

Promotion of co-operative work.—In the older States, whose soils have been exhausted by cropping, a most useful work is opened to the stations in field experiments with fertilizers. These experiments are conducted not only upon the station farms, but also by farmers upon their own farms under the direction of the stations. To aid the stations in this work, and at the same time to help in inaugurating soil studies, which will be useful as preliminary inquiries for the examination and classification of soils required by act of Congress, a call was issued by this Office for a meeting of the directors of the experiment stations east of the Mississippi river. The meeting, held at the Department, March 5 and 6, was attended by representatives from the Maryland, Pennsylvania, Connecticut (State and Storrs), Massachusetts (Hatch), Georgia, West Virginia, South Carolina, Delaware, Minnesota, Indiana, Ohio, and New Hampshire Stations. The following recommendations for co-operative field experiments were adopted:

(1) That for the present soil tests with fertilizers, made upon some such plan as recommended in Bulletin No. 1 of the Storrs School Agricultural Experiment Station, be made a leading feature of this work.

(2) That such plan, when adopted, provide for the use of uniform kinds and quantities of fertilizing materials, based upon analysis of the fertilizers used.

(3) That experiments be continued throughout a series of years, when practicable, and that the fertilizers be repeated on the same plats year after year while the particular crops used be left to the discretion of the stations.

(4) That both manured and unmanured plats be duplicated to as great an extent as may be found practicable.

(5) That in distribution of such experiments regard be had to the surface geology of the State.

(6) That reports upon such experiments should contain as full information as can be furnished respecting the geological origin and history of the soil on which they may be made, its physical and chemical condition, the fauna and flora of the region, and also as full meteorological data as can be obtained.

The results of the discussions were published in Circular No. 7 of this Office, for which the secretary of the meeting, Director Thorne, of Ohio, furnished a report, and the director of the Office prepared explanations and directions for soil tests with fertilizers, suggestions for special nitrogen, phosphoric acid, and potash experiments, and brief articles on the sources of error in field experiments and the kinds of experimental inquiry needed.

The Office has also acted with the committee on co-operative work in horticulture appointed at the Knoxville meeting of the American Association of Agricultural Colleges and Experiment Stations in collecting and publishing a list of originators of fruits, vegetables, etc., in the United States (Circular No. 6); in preparing and publishing forms for horticulturists' reports on fruits and vegetables (Docs. 11, 12, and 13); in calling a meeting of station horticulturists, which was held at Columbus, Ohio, June 13 and 14; in preparing and publishing a report of their meeting (Experiment Station Bulletin No. 3); and in collecting and publishing a list of station horticulturists and accounts of the horticultural work at the several stations (Experiment Station Bulletin No. 4).

The Columbus meeting was attended by representatives of the Virginia, New York (Cornell), Maryland, Pennsylvania, Ohio, Michigan, and Indiana stations, and by the assistant director of this Office.

The results of the meeting are thus summarized in the report of the assistant director (Experiment Station Bulletin No. 3):

The main question, regarding co-operative tests of varieties, was thoroughly discussed in detail. It was decided that stations ought not to *buy* new varieties; that uniform methods of note-taking were probably not practicable; that in reporting results to the public the stations should adhere to the forms provided by the Office of Experiment Stations of the Department of Agriculture; that a guarantee should be given to originators that the stations should not distribute new varieties to the public; that stations should insist upon the privilege of furnishing new varieties to each other.

Two other matters are worthy of special note. The first is the decision that the reports of tests of varieties by the various stations should be published collectively by the Office of Experiment Stations. The reason for this decision is that the value of this kind of horticultural work to the general public is greatly increased by the union in a single publication of reports from a large number of points within a wide area. The second is the appointment of a committee on nomenclature, to regulate, if possible, the naming of new varieties of vegetables with a view to preventing the use of foolish or laudatory names.

PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

The principal work of the Office thus far has been that involved in the collecting and preparing of material for publication. The publications issued or in course of preparation are divided into six classes:

(1) The Experiment Station Record, issued in parts and containing brief abstracts of the current publications of the stations, together with matters of kindred interest.

(2) Experiment Station Bulletins, intended for station workers and others specially interested in agricultural science.

(3) Farmers' Bulletins, containing accounts of experiment station work and cognate information in brief, popular form. These are intended for general distribution to farmers and others.

(4) Miscellaneous Bulletins, treating of a variety of subjects more or less intimately related to the stations and agricultural colleges.

(5) Monographs on special topics in agricultural science.

(6) Circulars, containing matters of transient or restricted importance, and usually intended for limited circulation.

The following documents have been issued by this Office:

Doc. No. 1, Circular No. 1.*—List of Agricultural Experiment Stations in the United States, with addresses; issued February 1, 1889.

Doc. No. 2, Circular No. 2.*—Regarding meeting of Eastern and Southern Stations to discuss co-operative field experiments; issued January 31, 1889.

Doc. No. 3, Circular No. 3.*—Regarding originators of fruits, etc.; issued February 6, 1889.

Doc. No. 4, Circular No. 4.*—Memorandum for Station Reports; issued February 12, 1889.

Doc. No. 5, Experiment Station Bulletin No. 1.—Organization of the Agricultural Experiment Stations in the United States; issued February, 1889.

Doc. No. 6, Circular No. 5.*—Call for meeting of stations for discussion of co-operative experiments; issued February 25, 1889.

Doc. No. 7, Circular No. 6.*—List of originators of fruits, vegetables, etc., in the United States; issued March 8, 1889.

Doc. No. 8, Circular No. 7.—Co-operative field experiments with fertilizers; issued March, 1889. This contains the report of the conference of representatives of stations regarding co-operative field experiments with fertilizers, directions and explanations for soil tests with fertilizers, and suggestions for further experiments.

Doc. No. 9, Circular No. 8.—Explanations and directions for soil tests with fertilizers; March, 1889. This is intended for the use of farmers experimenting under the direction of the stations. It is included in Circular No. 8, but was also printed separately for convenience.

Doc. No. 10.*—Letter of advice concerning blank forms for reports of horticulturists; issued April 15, 1889.

Doc. No. 11, Form 1.*—Horticulturists' blank for vegetables; issued April 15, 1889.

Doc. No. 12, Form 2.*—Horticulturists' blank for fruits; issued April 15, 1889.

Doc. No. 13, Form 3.*—Blank for report of horticulturists; issued April 15, 1889.

Doc. No. 14, Circular No. 9.*—Memorandum of information for a report on Farmers' Institutes in the United States; issued May 10, 1889.

Doc. No. 15, Miscellaneous Bulletin No. 1.—Proceedings of Association of American Agricultural Colleges and Experiment Stations at Knoxville, Tenn., January, 1889.

Doc. No. 16, Farmers' Bulletin No. 1.—The What and Why of Agricultural Experiment Stations; issued June, 1889.

Doc. No. 17, Experiment Station Bulletin No. 2.—Digest of Annual Reports of Stations in the United States for 1888, Part I; issued June, 1889.

Doc. No. 18, Circular No. 10.*—Asking for accounts of special work in horticulture; issued July 1, 1889.

Doc. No. 19, Experiment Station Bulletin No. 3.—Report of Meeting of Horticulturists at Columbus, Ohio; issued July, 1889.

Doc. No. 20, Circular No. 12.*—Regarding the library and publications of the Office of Experiment Stations; issued July, 1889.

Doc. No. 21, Circular No. 11.*—Rules for naming vegetables, report of Committee of Experiment Station Horticulturists; issued September, 1889.

Doc. No. 22, Experiment Station Record, Vol. 1, No. 1.—September, 1889.

Doc. No. 23, Circular No. 13.*—Regarding meetings of Station specialists; issued October 16, 1889.

Doc. No. 24, Circular No. 14.*—Letter announcing meeting of Association of Economic Entomologists.

Doc. No. 25, Experiment Station Bulletin No. 4.—List of Horticulturists of the Agricultural Experiment Stations in the United States; issued November, 1889.

Besides the publications on field experiments and on horticulture already explained in the account of co-operative work, the following seem to require special notice:

Farmers' Bulletin No. 1, The What and Why of Agricultural Experiment Stations, comprises in 16 pages a brief statement of the history, work, and aims of the stations under the following topics: What the stations are for; what the stations do; origin and development of the stations; the European stations; what the American stations are doing; the Office of Experiment Stations of the Depart-

* Not intended for general distribution.

ment of Agriculture; publications; and appendix, containing a list of agricultural experiment stations in the United States, with names of directors and addresses. The demand for this bulletin has exceeded expectation. An edition of 50,000 copies was soon exhausted. Over 25,000 copies more have been asked for in different States, but the limited printing fund of the Department has thus far prevented the issuing of a second edition.

Experiment Station Bulletin No. 2.—Digest of Annual Reports of Stations in the United States for 1888, *Part* 1.—This contains such summaries of the annual reports of thirty-three stations as would naturally be included in a permanent record of their work, and an index of subjects, which, in accordance with the plan of this publication, may serve as an index not only of the digests, but also of the reports themselves. In this digest the effort is to reflect as accurately as may be the accounts which the stations render of their work.

The manner in which this publication has been received by the stations and the press indicates general approval of the effort to condense and index the mass of printed matter issuing from the stations.

The Experiment Station Record.—From many quarters have come requests for a periodical appearing at short intervals and containing brief accounts of the current work of the stations, of the Department, and of kindred institutions in this country. The first number contains abstracts of the bulletins of fifteen stations from January to June, 1889, inclusive; a list of the publications of the Department from January to August 15, 1889; and a list of the station bulletins of 1889, received by the Office during the same period. The numbers will be issued with continuous paging, so that those of a year may be bound together in a single volume with a thorough index.

Monographs.—When the Office was first organized plans were laid for the publication of several monographs. Their preparation was promptly begun, and has been carried on steadily during the year. This work is more fully noticed elsewhere.

Miscellaneous publications.—The proceedings of the Association of American Agricultural Colleges and Experiment Stations at the Knoxville meeting (January, 1889), and other publications of this kind have been edited by the office and published by the Department. Such help is warmly appreciated and should be encouraged.

PUBLICATIONS IN COURSE OF PREPARATION.

The following are nearly ready for publication:

Bulletins on swine feeding.—These are being prepared with the co-operation of Profs. H. P. Armsby, of Pennsylvania, W. H. Brewer, of Connecticut, W. A. Henry, of Wisconsin, J. W. Sanborn, of Utah, and other specialists. The purpose is to give the principal results of experiments made in this country up to the present, and a brief review of similar work in Europe. Two bulletins are planned: an experiment station bulletin or monograph, with somewhat detailed accounts of the experimental inquiry; and a farmers' bulletin, to give the practical outcome of the investigations in brief popular form.

Monographs on the nutrition and feeding of domestic animals.—These are being prepared by co-operation with a number of specialists. Their purpose is to summarize results of later research, both European and American, and to serve as works of reference for ex-

perimenters and students. The compilation of results of experiments on swine feeding will constitute one number of the series. Prof. H. P. Armsby, of Pennsylvania, it is expected, will prepare other treatises on feeding for special purposes; Prof. W. H. Jordan, of Maine, is writing the portion on digestion and digestibility of feeding stuffs; Dr. E. H. Jenkins, of Connecticut, is collecting analyses of feeding stuffs. An introduction on the general principles of animal nutrition is being written by the director of this Office, and partial arrangements have been made for other contributions.

Organization list of stations and colleges.—Experiment Station Bulletin No. 1 contained, with other matters, a list of members of the governing boards and working staffs of the various stations. Its general approval and usefulness led to the preparation of a revised list giving the changes that have taken place since its issue. The recent convention of the Association of Colleges and Experiment Stations requested by resolution the publication of similar lists of the faculties of the agricultural colleges. As a large amount of experimental work in agriculture is performed by members of the college faculties, it was believed that these lists would be of use not only to the colleges but to the experiment stations and the general public. A bulletin containing lists for both stations and colleges will soon be issued.

Report on agricultural science and education in the United States.—The material for this was collected in connection with the preparation of a report of the Department of Agriculture presented with its exhibit at the Paris Exposition in 1889. It contains accounts of the establishment, history, equipment, and tendencies of the agricultural colleges and experiment stations of the United States; the names, titles, and work of members of the faculties and working corps; and brief details of the courses of study of the colleges and the lines of experimental work of the stations.

COLLECTION OF STATISTICS AND HISTORICAL DATA.

Experiment Stations.—As above implied, the Office has collected a large amount of material relating to the experiment stations, including their organization, revenues, governing boards, station staffs, farms, buildings, equipment, lines of experimental work, means for publishing results and disseminating information, history, results of past work, and aims and tendencies.

Agricultural colleges.—As the agricultural colleges are so closely related to the experiment stations and their work, the office has aimed to secure the catalogues and other publications of these institutions, and has also brought together a large amount of information regarding their organization, governing boards, faculties, number of students, courses of study, farms, buildings, equipment, revenues, expenses of students, history, aims, and tendencies. Besides serving for present needs, such data will be valuable for future reference.

Farmers' institutes.—In considering the methods by which the results of experiment station work are to be brought home to the farmers, the attention of this Office has been strongly attracted to the farmers' institutes, and in view of the general and increasing interest in these meetings in many parts of the country the collection of data regarding them from all sections of the United States has been begun. The material thus far collected relates to the acts of legislatures and rules of boards of agriculture and other bodies under whose authority

institutes are held; names, titles, and addresses of governing boards; names, titles, duties, and salaries of superintendents of institutes; relation of institutes to universities, colleges, and stations; lists of workers in institutes; plans for distribution of institutes; methods of making local arrangements; methods of procedure and programs of institutes; numbers in attendance; publications relating to institutes; methods of distributing publications; influence of institutes on farmers, agricultural colleges, etc.; and history of the general movement. The outcome emphasizes the important fact that what the farmers' institutes are now doing with great success is largely an extension and development of the work hitherto done by various organizations, such as boards of agriculture, agricultural societies, farmers' conventions, farmers' clubs, and agricultural colleges and experiment stations, for many years over a very large portion of the country. The movement is one of the most encouraging features of the agricultural and intellectual progress of our times.

WORK FOR THE COMING YEAR.

The demands upon the Office for the coming fiscal year are already large and varied. The correspondence, so important to stations, colleges, and private persons, must be maintained. As many stations as possible should be visited and farmers' meetings should be attended whenever practicable. The collating of lists of addresses to which the publications of the Office should be sent will demand all the labor that the Office can devote to this purpose. The collection and cataloguing of publications for the library should be continued and extended if possible.

Indexes of experiment station publications and kindred literature.—A general index of experiment station literature ought to be begun at once. The American publications, already very numerous, are rapidly increasing in numbers and importance. Several attempts to compile such indexes have been made by private individuals and libraries, but the task has been found too great. A letter just at hand from one of the best known of the station directors makes a strong plea for such an index, and expresses the opinion that the Office can do nothing more valuable and generally useful than to furnish such a work kept up to date. The call for such compilations is wide-spread and emphatic. The labor involved, however, is very considerable. It is hoped that means will allow this much needed work to be undertaken in the immediate future.

Experiment Station Record and Annual Digest.—A large share of the work of the Office during the coming year will consist in the preparation of the Experiment Station Record and Annual Digest. With the increasing number and complexity of the station publications this task grows continually heavier. The Office already receives from the experiment stations and from the bureaus and divisions of the Department of Agriculture publications varying in length from 4 to 450 pages each at the rate of nearly one per working day. To these must be added similar issues from the agricultural colleges and other institutions in which investigations of importance to the farming community are carried on in the United States and in Canada.

Compilation of results of European research.—One of the pressing needs of our experiment stations is that the fruits of European research shall be made available to them.

Experimental studies of the kinds in which our stations are now

engaged have been going on for nearly half a century in Europe. Universities, experiment stations, and agricultural societies; hundreds of chemists, physiologists, botanists, horticulturists, and farmers; the ablest men in science and the most successful men in practice have long been engaged in these lines of research. The accumulated material is already great and rapidly growing. The questions studied are similar in principle, and, to a large extent, identical in detail with those to which our stations are addressing themselves. Most of the results are printed in foreign languages and accessible to very few of our workers. Our stations are going over old ground and making old mistakes, and are unable to use their energies to the best advantage, because they have not the fruits of this experience to guide them. The necessity of bringing the results to our stations is apparent and has frequently been insisted upon. In the "Report of the Committee on Station Work of the Association of American Agricultural Colleges and Experiment Stations," published by the Department of Agriculture in 1888, special stress was laid upon this subject. At a recent meeting of the same association not less than three different resolutions were passed asking the Department for help in this matter.

Farmers' bulletins.—The experiment stations are for the agriculture of the whole country, and their products should be made as widely available as possible. Each station works upon problems of interest in its own region and distributes the results of its work among the farmers of its own State, but many of the results are of equal value in other States. There are a large number of important subjects upon each of which several stations are working. What is learned about the creaming of milk and the making of butter in Wisconsin and Iowa is useful in Maine and Oregon. Experiments on cotton production and the use of cotton seed for feed and fertilizers in Alabama may apply also in Tennessee and Texas. Experiments on the feeding of swine have been conducted by twelve agricultural colleges and experiment stations in as many States. A large number of questions have been tested by the use of different kinds of food and methods of feeding. One hundred and ninety trials have been made with one thousand three hundred and fifty animals of various breeds and ages. The results are of value to every breeder and feeder of swine in the United States.

The mailing lists of the several stations aggregate over two hundred thousand names and are rapidly growing. Their reports and bulletins number between two and three hundred per year. The individual stations can not afford to send their publications to all the farmers of the country who are interested in them; the individual farmer could not read them all if he had them, and if he did read them they would be far less helpful to him than publications in which the information from the different stations was collated, condensed, and put in convenient form for him to use. The same is true of the results of investigations in many of the lines in which different stations are working.

The Experiment Station Record and Digest of Annual Reports and not meet these requirements because of their technical character and the expense of large editions. To meet the need this Office has planned a series of Farmers' Bulletins, each intended to be "so plain that the ordinary man will understand it, so short that he will read it through, and so practical that he will take it to heart." One number of this series has already been issued, and although it is

meant to explain what experiment stations are, rather than to give results of their work, an edition of 50,000, as we have before stated, has been exhausted and requests are on file for some 25,000 more. To reach the farmers whose names are now on the mailing lists of the stations in the several States would require editions of 200,000 copies. This number would provide but one bulletin for each forty of the eight million men engaged in farming in the United States, or ten in a township of four hundred working farmers. The expense of printing 200,000 copies of such a bulletin would be about $2,500. Six numbers in a year would cost $15,000. This is a small sum for distributing information to obtain which the State and General Governments are spending $750,000 annually.

THE INDICATION OF SPECIAL LINES OF INQUIRY TO BE PURSUED BY THE STATIONS.

In accordance with the acts of Congress and the directions of the Secretary of Agriculture in conformity therewith it is a duty of this Office to indicate lines of inquiry to be pursued by the stations and to furnish such advice and assistance as will best promote their prosecution. As the enterprise develops throughout the country and the wants of the different regions and the means of meeting them become better known, it will be feasible to do this more and more successfully. Beginnings, however, have already been made.

Investigations of soils.—The act of Congress making appropriations for the experiment stations provides, "That as far as practicable all such stations shall devote a portion of their work to the examination and classification of the soils of their respective States and Territories, with a view to securing more extended knowledge and better development of their agricultural capabilities." The field experiments with fertilizers to test the needs of soils in different regions for the production of various crops, explanations and directions for which were published in Circular No. 7 of this Office, are a beginning in this direction. These experiments are especially in place in the older regions, where the soils have been worn down by long cultivation without proper tillage and manuring. They represent, however, but one of the many lines in which investigation of soils should be prosecuted. It is difficult to imagine anything more important for the future of the agriculture of the United States than a proper understanding of the wonderfully diverse soils of the country. To successfully prosecute the needed inquiries, the first requisite is a clear knowledge of what has already been done both at home and abroad, not only in the study of the soils of different regions, but also in the methods of inquiry. A large body of information has been accumulated during the past twenty-five years. The larger portion of it comes from European research. It has to do with meteorology as applied to agriculture; with the distribution of the flora and fauna of different regions, or what may be called "life areas;" with topography; with geology, in so far as that science reveals the origin and characters of different soils; with the physics and chemistry of the soil; and with the results of experience in tillage, manuring, cultivation of crops, and animal production.

The experience of the stations which have attempted soil investigations has brought out clearly the need of information in regard to the results already reached. This need found expression in the fol-

lowing resolution passed at the last meeting of the American Association of Agricultural Colleges and Experiment Stations:

Resolved, That we recognize the great importance of the investigations of the soils of the United States indicated by the act of Congress and by the recommendation of the Secretary of Agriculture, but we recognize also the difficulties involved in such investigations, and therefore request such aid as the Department may be able to furnish, including especially the collating and publishing of the results of investigations at home and abroad.

Investigation of feeding stuffs and foods.—Another line in which inquiry is especially demanded is the study of the food and nutrition of domestic animals and man. A great deal of experimenting has been done and is now in progress to discover the nutritive values of food materials, the laws of nutrition and their proper application. Experimental science has advanced to the stage in which more thorough inquiry into the fundamental principles of these subjects is necessary. Many analyses of feeding stuffs are being made by the stations, and standards for rations for domestic animals have been proposed and are widely used; but the results of actual feeding tests do not always agree with those obtained by analysis and recommended in feeding standards. While analyses of feeding stuffs by the methods now current have been and are of the greatest service, especially when combined with results of experiments upon digestibility and other physiological research, it is universally recognized by agricultural chemists that chemical analysis alone gives a very inadequate idea of the true nutritive value of a feeding stuff. The late advances in physiological chemistry all point to the possibility of getting such knowledge as will show feeding values with reasonable accuracy. One thing now especially needed is a thorough study of the chemistry of vegetable and animal products used for food. For this purpose it is essential to make more accurate separations of the proximate compounds and investigate them individually with reference to their molecular constitution and their potential energy. This means the most accurate, profound, and detailed research in analytical, organic, and physical chemistry. It will require much labor and that of the highest scientific order, but neither its magnitude, its difficulty, nor its cost should prevent its being undertaken and carried to successful issue. The interests of the agriculture of the country as well as of scientific advancement are too great to permit its neglect.

It has been urged by not a few of the best thinkers and wisest agriculturists and economists that in studying the food of animals we have no right to neglect the food of man. The principles involved are essentially the same. The majority of our people and practically all wage-workers spend and must spend at least half the money they earn for food. But very few have any just ideas of the effect of food upon health, or of its nutritive value, and the most intelligent know far less about the relation of that value to cost than of the relation existing between the value and the cost of clothing or other staple necessities of life. The need and the wisdom of such studies require no urging.

THE WORK OF THE STATIONS.

A general summary of the kinds of experimental work in which experiment stations in the different States have been engaged during the year 1889 is given on pages 534–536. The following statements, which may help to an understanding of the nature and value of the

experimental inquiries, are drawn from special reports made by the directors of some of the stations to this Office and from the publications of the stations. Of course no attempt has been made to cover all the points of interest or value presented by the current record of a year's work of the stations. The object is simply to touch here and there on such points as will indicate some of the ways in which the stations are endeavoring to aid the farmer. For a more complete showing of the scientific character and practical utility of such work resort must be had to the bulletins and reports of the stations and to those publications of this Office in which the station publications are summarized, especially the Digest of Annual Reports and the Experiment Station Record. Numerous references to station publications are given in this report in foot-notes, in which each station is designated by the name of the State in which it is located, *e. g.*, New York (Cornell) Station Bulletin No. 5 means Bulletin No. 5 of the Cornell University Agricultural Experiment Station at Ithaca, N. Y. A full list of the stations, with addresses, is given on pages 530–531.

The following from a special report of the director of the California Station may serve to illustrate the usefulness of station work, especially as conducted in a new region.

SOME FEATURES OF THE WORK OF THE CALIFORNIA STATION.

People living east of the Mississippi river have very little conception of the nature, number, and importance of the problems which confront new settlers or older farmers in California and other States west of the one hundredth meridian. California, with a coastline which would reach from Boston to Savannah or from London to Venice, presents a wonderful diversity of soil and climate. The Station is, therefore, forced to study a large number of fundamental problems from entirely new stand-points. From the outset of its work (in 1876) it has given much time to the study of soils.* Over twelve hundred samples have been examined, and have served as a basis for the classification of the lands of the State. Three outlying culture experiment stations have been established and equipped—one for the foot hills of the Sierra Nevada Range, one for the San Joaquin Valley, and one for the southern Coast Range. The land and buildings for these substations have been obtained by donations and subscriptions in the regions concerned, a good indication of the public interest in the work of the station in this State. A fourth substation for that region of the State in which Los Angeles, San Bernardino, and San Diego are representative towns, is contemplated. Most of the expense of the home work of the central Station at Berkeley is now, as it has been from the beginning, defrayed either from appropriations by the State legislature, or, as at present, directly from the University fund. The equipment and maintenance of the outlying culture stations are paid for from the Congressional appropriation. Besides the general culture stations mentioned, three exclusively viticultural stations have been established. They are maintained in part by private means. All these stations together do not represent more than half of the climatically different regions of the State.

Soil studies.—The following are some of the results already obtained from the investigations of California soils:

(1) In nearly all cases they are calcareous, that is, they contain

* The first summaries of results of this work were published in Vol. VI of the United States Census of 1880, and in the Report on Arid Lands of the Pacific Slope, U. S. Department of Agriculture, 1882.

such an amount of carbonate of lime as to impart to them the distinctive character of such soils, and to render the use of that substance in fertilizers superfluous and ineffective.

(2) The great majority contain amounts of potash largely in excess of those in the soils east of the Mississippi, and very often exceeding 1 per cent. Potash salts are also frequently found circulating freely in the soil water. The inference is that potash will not be generally needed as a fertilizer for a long time to come.

(3) On the other hand, phosphoric acid is found to exist in relatively small amounts in the soils of California as compared with Oregon, Washington, Montana, and the Eastern States. Phosphates, therefore, may be profitably used in many localities of the State. This has been confirmed by actual trial at the central Station, and by farmers; for while lime and potash salts have rarely been effective, phosphates have proven very useful on soils somewhat worn.

(4) Attention has been called to the broad fact, heretofore overlooked, that the accumulation of lime in the soil of arid regions is as necessary a consequence of the climate there prevailing as is that of alkali salts, and that such regions must, therefore, be expected ordinarily to have calcareous soils. This generalization has been amply verified by numerous analyses of soils from the States and Territories west of the one hundredth meridian made in connection with the Northern Transcontinental Survey, but thus far unpublished.

Analysis of water for domestic and manufacturing purposes.—The unfitness of numerous wells and springs for these purposes has been shown, and in some cases means have been devised for rendering such waters fairly good by appropriate processes.

Irrigation waters.—Important differences have been discovered in the mineral ingredients of the several streams used in this State for irrigation. The water of some is exceptionally pure (*e. g.*, the Mokelumne and King's rivers); others contain an excess of alkaline salts; others supply to the soil sufficient potash to replace all, or nearly all, of that withdrawn by crops. An examination of the waters of Tulare Lake showed their entire unfitness for irrigation purposes, and prevented the construction of costly irrigation works, which would have been worse than useless. It is now proposed to drain its waters off and use its bed for agricultural purposes. The territory affected by this question is as large as Connecticut and Rhode Island. The results of the examination of a number of artesian wells, yielding highly saline or alkaline water, have proved very important in their bearing upon the use of the water for irrigation.

Alkali lands.—The investigation of "alkali lands" with reference to their composition, reclamation, and the plants suitable for them, is of growing importance, not only because of their great fertility under the right treatment, but also because irrigation without proper drainage, and in some cases the nature of the subsoil, cause alkali to rise under cultivation where none was ever known before. The crude attempts to reclaim these lands by surface flooding, heavy manuring, etc., having resulted in failure, the Station undertook their investigation at the outset of its work, determined their nature, and indicated the means for their restoration to usefulness. The publications in 1880 and 1886 on this subject have been in large demand. The remedies suggested are largely based upon the lessening of the evaporation of water from the surface of the ground, the prevention

of the formation of crusts; and in case of the presence of the most noxious ingredient, carbonate of soda, application of land plaster, which converts it into a relatively harmless neutral salt. Analysis having further shown in most of the alkali lands large supplies of potash, phosphates, and nitrates, their high and lasting productiveness has been placed beyond cavil, and has, in numerous cases of intelligent treatment, been amply confirmed by experience.

Deposits of sulphate of lime.—In the hope of finding an abundant and cheap supply of land plaster, numerous samples of rocks have been sent to the Station and analyzed. In several cases the analyses have resulted in the finding of gypsum deposits, one of which, near Bakersfield, in Kern county, promises an abundant supply of this important material at reasonable prices.

The prevention of the useless expenditure of money on unprofitable ventures along these lines has at times been an important part of the work of the Station. In one case when a mill for the grinding of the impure limestone for use as a fertilizer was in course of erection on the strength of favorable reports from New England, the explanation that to apply limestone in a region whose soils already contained from 3 to 8 per cent of carbonate of lime would be as bad as "carrying coals to Newcastle" promptly caused the abandonment of the enterprise before much money was invested in it.

The sugar-beet in California—Water-melons.—It may be fairly claimed that the results of the persistent investigations at the Station showing the high quality of the sugar-beets grown in California has had its full share in the conversion of public and private opinion from sugar-cane and sorghum to the beet. A continuation of this line of research in connection with the newly established culture stations can not fail to lead to important results. Investigations published by the Station put an end to the proposition to manufacture sugar from the water-melon, to which the climate of the great valley of California is wonderfully adapted, and will, it is hoped, lead to the abandonment of the objectionable practice of sulphuring fruit.

Grape culture.—Since between three and four hundred varieties of grapes have been indiscriminately grown in the State, it has been an important part of the work of the Station to test the adaptation, bearing, time of maturity, liability to injury, quality and character of their product, whether for wine, raisins, or table use, and to prevent the confusion arising from the careless or fraudulent use of the wrong names for particular varieties.

From the three special viticultural stations valuable data have already been obtained for the several varieties. Some have proved worthless and others very valuable in the localities where they have been tried. A number of varieties grown under different names have been proved to be identical, and others grown under the same name to be entirely distinct. Newly imported varieties have been propagated for trial and distribution, *e. g.*, the Huasco Muscat grape of Chili, which is now grown in several localities in preference to the Alexandria Muscat.

The Station has studied the differences in the same variety due to difference of climate, with certain well-marked results. In appropriate soil and climate numerous varieties of the European grape show their reputed characteristics in California. On the other hand, some grapes that in the Bay climate of California produce highly colored wines, will in the dry and hot climate of the San Joaquin Valley lose that quality and suffer increase of tannin, decrease of acidity,

and other changes, so that only light-colored, astringent, and insipid dry wines, of little or no merit, can be made from them.

It has also been shown that, contrary to expectation, the foot-hills of the Sierra Nevada will not yield lighter wines than the Great Valley, even at an elevation of 2,000 feet. In this region some grapes have somewhat more color and ferment better than those grown in the Valley, and their wine has better keeping qualities. Both regions are manifestly best adapted to the growing of sherry, port, and raisin grapes, while the slopes and valleys of the Coast Range must be looked to for wines of the Claret, Burgundy, Sauterne, and Rhenish types, that have already obtained wide approval.

Wine making.—Elaborate experiments on the methods of wine making and kindred subjects have been conducted and reported by the Station. With the rest, methods of fermentation; wine colors and their progressive extraction from the grape-skins during fermentation; wine heating, or "pasteurizing;" and the electro-magnetic process of wine treatment have been studied with most interesting results. Much attention has been given to the detection of adulterations in wines, especially as regards the alleged artificial coloring and the addition of salicylic acid for preservation. To the credit of the California product it must be said that in but a few instances were such adulterations detected, and those mostly in samples from one and the same commercial source.

Introduction of trees valuable for California.—Of the varieties of North and South American, European, Australian, Chinese, Japanese, and other trees, with which the Station has conducted successful experiments, a few have been selected as worthy of especial mention. The lack of hard-wood timber suitable for the manufacture of agricultural implements, staves, etc., in California, early led the Station to experiment with the Eastern oaks, hickories, and other species valued as timber trees. The results indicate that the growth of these oaks and hickories is very slow and unsatisfactory, and that their introduction for timber culture is not to be encouraged. On the other hand, it has been shown that the European or English oak (*Quercus pedunculata*) makes a very rapid and satisfactory growth even in a very dry climate, provided the soil is deep enough to enable the tree to send its tap-root down to moisture. Reports received from different parts of the State regarding the growth of trees of this species from the acorns and seedlings distributed by the Station, make it seem probable that this oak will be the hard-wood tree of the future for the Pacific coast. The cork oak has also been extensively distributed, and promises to supply in the future one of the great needs of the wine industry.

The camphor tree of Japan and China seems also adapted to a large area of this region. Its growth is rapid. A tree in Yuba county in fourteen years reached a height of 50 feet. An especial advantage of this tree for ornament alone is its exemption from insect parasites, which, especially in the coast regions, trouble all our indigenous evergreens and materially stunt their growth.

Few species of trees seem as well adapted to our hot summers and drying winds as the various species of *Morus* that have been tried here. Especially can this be said of the *Morus japonica,* a species as valuable for food for the silk-worm as for shade. It far excels the *Catalpa speciosa,* which suffers from dry winds.

There can now be no question that with the English oak, the black wattle (*Acacia decurrens*), the black wood acacia (*Acacia melanoxy-*

lon), the camphor tree, and several species of eucalyptus (all rapid-growing trees), the entire Coast Range of California, so far as it has sufficient soil, can be covered with forest if desired; and the same is true of the Great Valley. Of trees of slower growth there are, of course, very many that could be used.

Grasses and forage plants.—The efforts of the Station to find forage plants and grasses adapted to the arid regions have met with great popular favor. For years there has been a constant call for perennial plants which will retain their verdure during the dry summer and survive much closer pasturing than annuals. Alfalfa (*Medicago sativa*) has long proved a priceless boon upon the naturally moist or irrigated lands of the interior and southern coast valleys, but does not make winter growth, nor does it thrive on the upland pastures of the dairy regions of the Coast Range. The Station, with its co-operating experimenters in different parts of the State, has, therefore, made wide trials with a large number of plants, including Schrader's brome grass and Hungarian brome grass (*Bromus unioloides* and *B. inermis*); New Zealand millet grass (*Milium multiflorum*); "Gazon" (*Paspalum dilatatum*); Texas blue-grass (*Poa arachnifera*); tall oat grass (*Avena elatior*); orchard-grass (*Dactylis glomerata*); perennial ray grass (*Lolium perenne*); and a new Japanese grass (*Agropyrum japonicum*). All these possess valuable characteristics and are coming into wide use.

Experiments with varieties of sorghum, especially "Amber" and "Orange" canes, of "Kaffir" and "Egyptian" corns, and of "Jersey kale," have demonstrated the possibility of securing with them on moist or irrigated lands a vast amount of summer feed, which is of inestimable value to dairymen in keeping up the flow of milk when the natural pastures are dry. The silo is now being introduced into the State with a view to the storage of forage plants grown in the winter and spring for summer and fall use—"a complete reversal of the dairy economy of the Eastern States."

Meteorology.—Observations are made at Berkeley by the department of civil engineering and astronomy of the University, and at the outlying stations by the foremen in charge.

Entomology.—Among the important investigations have been those connected with the introduction of vines resistant to the grape phylloxera, and of varieties of wheat resistant to the Hessian fly; warfare against scale insects; experiments in the use of insecticide gases, and especially of hydrocyanic gas in its application to citrus trees; analyses of alkalis and soaps offered for sale as insecticides, and the preparation of a standard formula for whale-oil soap.

Mycology.—Extended observations and experiments have been made on the *Oidium* of the vine and the proper use of sulphur as a remedy for this fungus; and on *Fusicladium dendriticum* and the prevention of this disease by spraying the trees with sulphide of soda and whale-oil soap.

Distribution of seeds and plants.—For nearly twenty years numerous varieties of native and foreign trees, shrubs, grasses, cereals, and forage, fiber, medical, and oil yielding plants have been propagated at the University, and the distribution of seeds and plants, begun on a small scale early in the history of the Station, has now attained large proportions. During 1889, packages containing several kinds of seeds of plants were sent to nine hundred and ninety-four applicants in all except two small mountain counties of the State. From the outset the Station has required applicants to pay a

small sum for packing and postage or express. These payments do not fully cover the cost of the distribution, but, it is believed, have served to make it more useful than it would have been if no charge had been made.

ILLUSTRATIONS OF STATION WORK BY TOPICS.

FERTILIZERS—THE WANTS OF DIFFERENT SOILS.

In the Eastern and Southern States, whose soils have been worn out by cropping without return of plant food, artificial fertilizers have become a necessity, and many millions of dollars are expended for them every year. There have been two great difficulties, however, in their purchase and use. Inferior wares have been offered for sale, and farmers have not known how to distinguish between the good and the bad, nor have they understood what materials best fitted the wants of their soils and crops. To put $10 worth of phosphate on an acre of land that does not need phosphoric acid, or to use that alone on a soil which needs nitrogen or potash as well as phosphoric acid, is to waste not only the money expended for the fertilizer, but the labor and the use of the land. Farmers have lost a great deal in the purchase of fertilizers of poor quality, but they have lost much more in buying and using materials not adapted to their wants.

Two things, then, are needed. First, commercial fertilizers should be sold on the basis of their actual composition as tested by analysis. Second, information is required as to the wants of soils and the materials which supply the lacking plant food most economically. But underneath these needs is a fundamental one, that the farmers themselves shall have an intelligent knowledge of the composition of fertilizers, the wants of their crops, the materials which their soils can supply, and the ways in which the elements of plant food, which their soils lack, and which neither tillage nor the manures of the farm can furnish, may be most advantageously supplied by artificial fertilizers.

The important rule is to make the most of the resources of the soil by proper tillage; to husband carefully the manurial products of the farm; to enlarge these by the purchase of feeding stuffs which make rich manure; and to buy commercial fertilizers to supply what is then lacking.

OFFICIAL EXAMINATIONS OF FERTILIZERS—FERTILIZER ANALYSIS.

The stations in some twenty-four States make analyses of commercial fertilizers under such regulations, in each case, as are prescribed by the State law, or the authorities of the station, or both. In some States the fertilizer control is exercised by agricultural boards or commissions, in connection with the stations or otherwise.

Fifteen or twenty years ago but very little was done to regulate the trade in commercial fertilizers in the United States. The materials were sold upon the basis of general recommendations rather than of actual composition. Some of the fertilizers in the market were absolutely fraudulent; others were of the best quality and sold at very reasonable prices. This state of affairs was unsatisfactory to manufacturer, seller, and consumer. The advocates of the establishment of experiment stations and the exercise of fertilizer examination by them cited experience in Europe, where the control by chemical analysis was so efficient that commercial fertilizers were bought and sold with the same confidence as were flour, or coffee, or

cotton cloth, and urged that the same result might be secured here. The improvement since that time has been noteworthy, and although the condition to-day is not all that is to be desired, it is safe to say that in the States where the fertilizer examination has been wisely instituted the results are all that were promised.

Methods of fertilizer inspection vary widely in different States and greater uniformity is much to be desired. In general, however, the State laws require that the fertilizers when sold shall be accompanied by a statement of their composition, that is to say, the amounts of the valuable ingredients, nitrogen, phosphoric acid, and potash, which they contain. Samples are collected by officers of the station and other parties, or are supplied by purchasers or dealers, and analyzed at the station or by a State officer. A comparison of the analysis of a given fertilizer as sold, with the statements or guarantees of composition, enables the purchaser to judge of its merit. It is also quite common to estimate the commercial or trade values of fertilizers by ascribing a given value per pound to each of the valuable ingredients. These trade values are based upon a comparison of the composition and cost of standard articles in the markets, and are revised from year to year.

The following is a simple example of the use of such valuations: Suppose a ton, of 2,000 pounds, of fine ground bone to contain 4 per cent of nitrogen and 25 per cent of phosphoric acid, or, in other words, 80 pounds of nitrogen and 500 pounds of phosphoric acid; at a trade value of 16½ cents per pound the nitrogen would be worth $13.20, and at 7 cents per pound the phosphoric acid would be worth $35, making the total market value of the ton of bone $48.20. If the farmer bought this bone in the market in 1889 for a price which did not exceed $48, he could not fairly complain that he was getting less than his money's worth of nitrogen and phosphoric acid in the bone. But if his land did not need such a fertilizer he wasted his money in buying bone at any price. For this, however, the farmer himself, and not the dealer in fertilizers, is, of course, responsible.

The advisability of publishing the estimated values per ton with the analyses of fertilizers has been called in question. It has been urged, with justice, that by these means the attention of the farmer is drawn away from the actual composition of the fertilizer, and directed only to a pecuniary estimate which can not be in all respects satisfactory as a measure of the market value, and is very far from a correct measure of the agricultural value, *i. e.* the benefit which will come from the use of a fertilizer in any given case. A fertilizer law lately passed by the Massachusetts legislature practically does away with this method of estimating values per ton, and provides only for publication of the results of the analyses and the guarantees.

IMPROVEMENT IN COMMERCIAL FERTILIZERS.

In Connecticut the farmers are especially interested in manures and fertilizers. The Connecticut Station has, therefore, naturally devoted a large share of its attention to commercial fertilizers. The result has been that inferior materials have been driven from the markets of the State, and not only that, but the farmers have been taught much concerning the relative values of the materials they buy or produce for feeding their crops, and how to utilize them most advantageously.

When the Station began its work in 1875, a number of brands of fertilizers then being sold in the State were analyzed and their com-

position compared with the selling price. It appeared that, at the rate farmers were paying, the nitrogen cost from 10⅓ cents to $1.67, and the soluble phosphoric acid from 10¾ to 25½ cents per pound. The report of the Station for 1888 shows that the nitrogen in the fertilizers sold in the State in that year cost from 12 cents to 18 cents, and the soluble phosphoric acid from 8 cents to 8½ cents. There were no fraudulent articles in the market. Connecticut farmers pay over $200,000 yearly for the phosphoric acid of commercial fertilizers. In this item alone the Station saves more than its cost.

In the annual report of the North Carolina Station for 1888 it is stated that in 1877, when the Station was established, the average cash price of the ammoniated fertilizers was $43.50 per ton. This same fertilizer in 1888 could be bought for $27.50, a reduction in price of $16 per ton. It is not claimed that the Station was the sole cause of this reduction, but that it aided largely toward this end by a judicious control of the trade, which resulted in the renewal of confidence between the dealers and consumers, in the prevention of fraud, and in the production of healthy competition.

The New Jersey Station (in its annual report for 1888) reports that, from the nearest estimates the Station can make, about 33,600 tons were sold to the farmers of that State during 1888, with a value of $1,125,800. The analyses show that the respectable manufacturers are becoming more careful to make their goods conform closely to their published guarantees of composition. But few brands of spurious or of greatly overrated fertilizers were sold in that year, and these must have been in very small quantities.

HOME-MIXED FERTILIZERS.

In some localities where farmers have become expert in the use of the results of the analyses of fertilizers through field experiments and other experience, the advisability of mixing the fertilizers at home is actively discussed.

The question is whether it is better for the individual farmer to buy the raw materials and compound his fertilizers, or to buy them already mixed in the form of ammoniated superphosphates, "complete fertilizers," and other special fertilizers for different crops, prepared by formulas of one kind or another. The analyses of fertilizers offered for sale in the markets show the quantities of nitrogen, phosphoric acid, and potash, and the forms of combination of these ingredients, *i. e.* whether the nitrogen occurs as nitrate in nitrate of soda, or as sulphate in sulphate of ammonia, or as organic nitrogen in dried blood, tankage, fish scrap, etc.; phosphoric acid as soluble or insoluble; superphosphate in bone, raw phosphate, or other material; and potash in muriate, kainit, or other German potash salts. Comparison of the composition with the price per ton shows the cost of a pound of each valuable ingredient. The purchaser can either mix at home the nitrogen, phosphoric acid, or potash in nitrate of soda, dried blood, fish, phosphate, bone, or potash salts, selected in the materials which furnish him these valuable ingredients in the forms and quantities he desires and at the least cost; or he can buy the mixtures already compounded in the various brands of commercial fertilizers offered for sale.

The Connecticut Station has made a study of this matter by analyzing samples of home-mixed fertilizers and comparing their composition and cost with those of the fertilizing materials as sold in the

markets. The results are published in one of the bulletins of the Station,* from which the following statements are quoted:

The average cost of materials for the fertilizers referred to in this bulletin has been $33.79 per ton, delivered at the purchaser's freight station. Two dollars will fully cover the cost of screening and mixing. (From $1 to $1.50 is the estimate of those who have done the work.) At the highest estimate, therefore, the average cost of these home-mixed fertilizers has been $35.79 per ton. The average valuation has been $38.83 per ton. In no case has the valuation been less than the cost of the chemicals mixed. The valuation of ready-mixed fertilizers, on the other hand, is quite uniformly less than their cost.

The advantages claimed for home-mixing are:

(1) Each ingredient can be separately examined by the purchaser, and, if necessary, sent to the experiment station for analysis. The detection of inferior forms of nitrogen or phosphoric acid is much easier and more certain in a single article than in a mixture.

(2) It is self-evident that an intelligent farmer, by home-mixing, is better able than any one else can be to adapt the composition of his fertilizers to the special requirements of his land as well as of his crop; and how greatly the soil requirements vary in this State, even over a small area, is strikingly shown by the field experiments annually reported by our farmers through the stations.

(3) It is claimed that the same quantity and quality of plant food costs much less in home-mixtures than in ready-made mixtures, because the cash purchaser of fertilizer chemicals deals directly with the importer or manufacturer, not with the middle-man or retailer, and receives quotations without reference to the prices asked in his neighborhood by retailers of the same goods.

There is no longer any question as to the expediency of home-mixing in many cases. From such raw materials as are in our markets, without the aid of milling machinery, mixtures can be and are annually made on the farm which are uniform in quality, fine and dry, and equal in all respects to the best ready-made fertilizers.

The economy of home-mixing depends, of course, on the prices which sellers of mixed goods are willing to take and on the cost of fertilizer chemicals delivered as near the farm as mixed goods can be bought. There is always a chance for the farmer who studies the market and the needs of his farm to save enough in the purchase of his fertilizers to make just the difference between profit and loss on a crop; and in farming, as in everything else where competition is close, profit usually comes from care in these small margins of expense. Perhaps home mixtures are not, indeed, always and everywhere cheaper or more economical than commercial mixtures, but it will often happen that money can be saved by the timely purchase of raw materials and their mixture on the farm. Each individual farmer ought to be the best or only judge of the economy of home-mixing in his particular case, as well as of the "formulas" which are best adapted to his soil and crops.

ASHES AS A FERTILIZER.

The following statements are from one of the bulletins of the Connecticut Station,† which gives results of a considerable number of analyses:

Ashes vary a good deal in composition. * * * The ashes from household fires in New England as a rule contain more potash and phosphoric acid than Canadian or Western ashes.

Leached and unleached Canada ashes have approximately the following percentage composition:

	Unleached ashes.	Leached ashes.
Sand, earth, and charcoal	13.0	13.0
Moisture	12.0	30.0
Carbonate with some hydrate of lime	61.0	51.0
Potash (chiefly as carbonate)	5.5	1.1
Phosphoric acid	1.9	1.4
Other matters by difference	6.6	3.5
	100.0	100.0

* Connecticut (State) Station Bulletin No. 98.

† Connecticut (State) Station Bulletin No. 100.

It appears from this statement that more than half the weight of both leached and unleached ashes consists of lime, partly as hydrate but chiefly as carbonate, which is the same material chemically as chalk or limestone, but finer, and so likely to be quicker in its action.

It has long been known that chalk or limestone may benefit both very heavy and very light lands, making the one looser in texture and less apt to puddle, and the other closer and more compact. It does this in the one case by separating the particles of sticky clay and in the other by filling up the interspaces of a coarse soil. A writer on agriculture in the early part of the last century says of chalk: "It causes great fertility, especially on such lands as are apt to lose the riches of dungs laid on them and to forget in a little time that they have had any kind and indulgent benefactor. Here chalk is of excellent use to drive away such ingratitude, having a retentive quality to inclose and stay the salts."

It needs to be borne in mind that potash or soda lye binds a clay soil, making it heavier, more tenacious and cloddy than before, and it may be that on this account a heavy application of *unleached* ashes to a clay soil would either not help it at all or even damage it, while on light soils unleached ashes would be more beneficial than leached ashes. This favorable action on light soils has made ashes popular in this State, where our soil is for the most part light and sandy. They "keep the soil moist," as the saying is; that is, by filling up the pores and compacting it the soil water is made to rise more readily in it from the subsoil, bringing plant food with it and preventing drought.

Besides this action of ashes, which is in large part at least mechanical, they also tend to correct "sourness" of the soil. In most cases this is not due to free acid but to the presence of soluble iron salts, which in undue quantity are poisonous to plants, and in smaller quantities show that the soil is stagnant and needs aeration. Ashes precipitate these salts and open the soil that contains them to the air by making it looser in texture.

When potash salts have been used in large quantities and the potash has been largely taken up by a rapidly growing crop, as tobacco, leaving most of the acid with which the potash was combined in the soil, ashes or lime may profitably be used to neutralize it. Our best tobacco growers use stone lime or cotton-hull ashes largely on their tobacco land with excellent results.

A third way in which ashes benefit land is in promoting nitrification; that process by which the more or less inert nitrogenous matters in the soil are made to yield nitrates, from which our field crops obtain most, if not all, their nitrogen supply. This process is in some way connected with the life of low organisms, which are invariably present in fertile soils. Nitric acid can be produced, however, only when carbonate of lime is present to supply a base with which the acid may combine, and a soil mildly alkaline is the one most favorable to the growth of these organisms and the formation of nitrates.

Such is, in brief, our present knowledge regarding the action of ashes. It is clear that the quantities of potash and phosphoric acid present do not wholly measure the value of ashes, nor does it pay to buy them simply to supply a deficiency of these two things in the manure. The quantities of potash and phosphoric acid in a ton of ashes, costing $12 to $15, can be bought in the form of muriate of potash and superphosphate of lime for $8 or $9. But ashes temper certain soils, making them easier to work, moister, and more retentive of manure, correcting "sourness," promoting the solution of plant food in them and so preparing the way for the use of fertilizers which directly applied might be wasted. To accomplish these ends ashes have to be used in considerable quantity, and probably a single heavy dose would help more than the same quantity applied in fractions through three or four successive years if the object is to change the mechanical condition of the soil strikingly.

The main points may be summarized thus:

(1) A large part of ashes, leached as well as unleached, consists of carbonate of lime, which may benefit land in three ways: First, it binds loose soils and makes them hold moisture, and on the other hand makes clay soils less stiff. Second, it corrects "sourness" in the soil, caused either by soluble iron salts or mineral acids. Third, it favors nitrification.

(2) Hence the value of ashes never wholly nor always chiefly consists in the plant food which they contain.

(3) It is possible that a heavy application of unleached ashes might injure a heavy clay soil by reason of the alkali in them.

FIELD EXPERIMENTS WITH FERTILIZERS—SOIL TESTS BY FARMERS.

The chemical analysis of soils is in some cases, notably in the newly settled regions, an efficient means for determining their needs, and

there is good ground to hope that research will help to make it much more generally useful than it now is. But experience in the long cultivated regions of the Eastern States has shown, that, on the whole, the most convenient way to test the wants of a given farm or field where artificial fertilizers are to be used is to put the question to the soil with different fertilizing materials and get the answer in the crop produced. This principle has been followed by a number of stations and by many farmers in the Eastern and Southern States.

In March, 1889, in response to an invitation by the Office of Experiment Stations, under the authority of the Secretary of Agriculture, the directors of a number of stations especially interested in field experiments with fertilizers met at the Department of Agriculture, in Washington, for conference regarding plans for co-operative work. Uniform plans for soil tests with fertilizers, to be conducted by farmers under the direction of the stations, were agreed upon, and arrangements were made for other field experiments. These plans are essentially the same as have been followed by some of the stations for a number of years past.

DIFFERENCES IN SOILS AND CROPS AS TO PLANT FOOD NEEDED.

The results of work in this line have shown the wide differences in the needs of different soils. In some cases fertilizers supplying phosphoric acid, such as superphosphate and bone, have proved extremely beneficial; in others they have been almost useless. The same is true of fertilizers containing potash and nitrogen.

Superphosphate, either alone or with farm manures, has in some instances made a remarkable increase in the crop, while in others it is without effect. In not a few cases a dressing of potash salt in the form of muriate has been remarkably effective. Frequently a mixture of different materials is found essential, and often a so-called "complete fertilizer" has been found most profitable. The great advantage is in finding what materials fit the special needs of particular soils and what forms and amounts of the fertilizers may be most economically applied. The fundamental principle in the use of commercial fertilizers is to select those materials which supply in the best forms and at the lowest cost the plant food which the crop needs and the soil fails to furnish.

POTASH IN FERTILIZERS.

In New Hampshire* soil tests were conducted on the Station farm during four years (1885–88) with a variety of fertilizers. In general the results indicate that on this soil potash led in effectiveness, with phosphoric acid second, and nitrogen last. In experiments with clover, it was shown here, as in England by Lawes and Gilbert, that the yield of hay followed very closely the per cent of potash in the fertilizer. The development of clover where mineral fertilizers, especially those containing potash, were used, coupled with the fact, which may be regarded as pretty well established, that leguminous plants obtain nitrogen from the air, makes the use of such fertilizers a very important matter in regions like this. In New Jersey† co-operative soil tests have been carried on by the Station and farmers under its direction in different parts of the State for nine years.

---

* New Hampshire Station Bulletin No. 5.
† New Jersey Station Bulletin No. 54.

Nitrate of soda, superphosphate, and muriate of potash, singly, two by two, and all three together, were used in these experiments, together with plaster, kainit, and fine barn-yard manure. With sorghum other fertilizers and combinations were added. Some of the results may be thus summarized:

Corn.—Experiments by Messrs. Thompson and J. Voorhees for five years on all parts of their farms confirm the conservative conclusions reached in 1882 and 1883, that while all fertilizing elements are effective, potash is by far the most profitable for corn. The experience of Mr. Thompson also indicates that kainit is more economical than muriate of potash.

Sorghum.—The following is a summary of experiments on sod ground in different parts of the college farm from 1881 to 1885, inclusive, republished from the annual report of the Station for 1885:

Yield of sorghum.—(1) Without exception, muriate of potash has increased the weight of the crop. (2) This increase has annually exceeded that caused by phosphoric acid and nitrogen, used singly and in combination, and with one exception, that caused by a combination of phosphoric acid and potash. (3) With two exceptions this increase has exceeded that caused by nitrogen and potash; by nitrogen, phosphoric acid, and potash; and by twenty tons per acre of barn-yard manure.

Yield of sugar.—Without exception, muriate of potash has increased the total yield of sugar per acre, and this increase in every case exceeded that caused by combinations of nitrogen and phosphoric acid, or of nitrogen, phosphoric acid, and potash, and with a single exception, that caused by combinations of phosphoric acid and potash. "The results secured from similar experiments on sorghum at Rio Grande, Cape May county, during 1885, 1886, and 1887, corroborate the above statements in nearly every particular, and admit of the conclusion that *potash is the element which exerts the most marked effect upon the yield of sorghum and upon the production of sugar.*"

Sweet-potatoes.—An experiment with fertilizers on crops in a four years' rotation, begun in 1882 by Mr. A. P. Arnold, has shown the favorable effect of potash on sweet-potatoes, as indicated by the crop of 1883, and its effect in improving the crop-producing power of the soil, as indicated by the second crop of sweet-potatoes in 1887. The soil of this farm is a very sandy loam, easily tilled and responsive to fertilizers, and especially suitable for sweet-potatoes, berries, and small fruits. "Commercial fertilizers are recognized as necessities and are used as freely as good management will warrant." At the close of the first rotation in 1885, the following conclusions with reference to potash were reached:

(1) Potash used alone greatly increased the profits. In this case the net value of increase was equal to 180 per cent on the cost of the muriate of potash used.

(2) Potash in combination with nitrogen and phosphoric acid, respectively, was also profitable, while the combination of nitrogen, phosphoric acid, and potash, though it required the largest investment, yielded the largest profit, namely, 110 per cent, on the market value of the "complete potato manure" used.

In 1887 the improvement in the value of the sweet-potato crop due to the continued use of potash varied from 8 to 107 per cent on the different plats. "In the cases where potash was excluded, the decrease in the value of the second potato crop was serious, ranging

from 36 to 63 per cent." Muriate of potash caused an improvement of 35 per cent in the crop-producing power of the plat on which it was used, as well as a large increase in the net value of the crops produced, so that the increase in the crop-producing power of the land was gained without sacrifice of any kind.

POTASH ON THE BLUE-GRASS SOILS OF KENTUCKY.*

The Kentucky Station has instituted several series of experiments with different fertilizing materials to test the needs of the soil of its farm, which is in the Blue-Grass region.

Fertilizers containing nitrogen, phosphoric acid, and potash, singly and in different combinations, have been tried upon corn, hemp, potatoes, and other crops. With corn there was a profit wherever potash was used and a loss wherever it was omitted. The phosphoric acid and nitrogen appear to cause little if any increase of yield, showing that the money paid for them was unprofitably expended. It appears that for corn potash is especially needed on the soil of the Station farm. Other experiments imply that the same is true for potatoes, hemp, and other crops. The indications are that wheat would be greatly benefited by the application of potash. A natural inference is that on soils of like character throughout the Blue-Grass region potash will be useful, but of course the actual demonstration of this must be made by extended trials.

Professor Scovell, director of the Station, states:

> There were last year legally on sale in this State forty-three different brands of fertilizers, containing less than 2 per cent of potash; if we had applied any one of these to our soil for corn, no marked increased yield would have been apparent, not because the fertilizers were worthless (as they undoubtedly would have produced good results on soils deficient in phosphoric acid and nitrogen), but because they did not contain the potash necessary for the corn crop on our soil.

TESTS OF VARIETIES.

Tests of varieties of field crops, such as corn, are commonly made on small plats under conditions to secure, as far as practicable, uniformity of soil, moisture, manuring, cultivation, and season of growth. The test may be made to determine the quantity of the product, time of maturity, or adaptability to climate and soil of a particular locality; or several or all of these points of comparison may be included in a single test. It is, of course, quite difficult to obtain accurate results in such work, since many things, such as drought, unusual cold or heat, or unknown inequalities in the soil, may render the experiment an unfair test. It is only after such trials have been made with great care for a number of successive years that any confidence can be felt in the certainty of the results. The following brief résumé of tests of varieties of corn at several of the stations may serve to illustrate what is being done in this line of work. Similar statements might be made for wheat, potatoes, and other crops.

Corn—Tests of varieties.†—As the result of tests of one hundred and

---

* Kentucky Station Bulletins Nos. 17 and 21.

† Alabama Canebrake Station Report, 1888; Colorado Station Report, 1888; Illinois Station Report, 1888, and Bulletin No. 4; Indiana Station Report, 1888, and Bulletin No. 23; Kansas Station Report, 1888; Minnesota Station Report, 1888, and Bulletin No. 7; Ohio Station Report, 1888; Pennsylvania Station Report, 1888, and Bulletin No. 7; South Dakota Station Report, 1888, and Bulletin No. 9; Vermont Station Report, 1888.

sixty varieties of corn at the Illinois Station, those named below are recommended for cultivation in that State. The varieties are divided into early, medium, late, and non-maturing, with reference to the latitude of the Station. Those varieties maturing in one hundred and twenty-five or less days from date of planting are considered early; those maturing in from one hundred and twenty-five to one hundred and thirty-five days, medium; those maturing in from one hundred and thirty-five to one hundred and forty-five days, late. When corn became sufficiently hard not to be sensibly injured by frost it was considered mature.

Early maturing varieties for northern Illinois.—Murdock (synonyms, Prairie Queen, Will's Ninety-day, Goddard's Favorite, Dammell's Bonus Prairie, Queen of the Prairie, Yellow Clauge, also in central Illinois as an early variety); Sibley's Pride of the North; North Star; Golden Rod; Edmond's Corn (also in central Illinois as an early variety); Kane County Pride (synonym, Zeigler's Ninety-day); King of the Earliest (synonym, Dakota Ninety-day); Hill's Improved Ninety-day; Champion of the North (synonym, Ninety-day White); Smith's Mixed Dent, Smith's Improved White, Smith's Improved Striped (also in central Illinois as an early variety).

Medium maturing varieties, for central Illinois.—Legal Tender; Riley's Favorite; Leaming (synonym, Iowa King); Clark's One Hundred-day; Seek-no-further; Champaign; Log Cabin; Burr's White (synonyms, Giant Normandy, Dresback, Champion White Pearl, Zeigler's Ninety-day, White Queen, Smith's Favorite, Hugh's Choice); Gourd Seed.

Late maturing varieties, for southern Illinois.—McConnell's Improved Orange Pride (probably desirable); Swengel Corn; Steward's Improved Yellow Dent (probably desirable); Piasa Pride (on fertile river bottoms, probably desirable).

Comparative tests of Burrill and Whitman silage corn (a large, late, or non-maturing southern variety) and Burr's White (a common medium-maturing dent variety) indicated that while the former gave a total yield of corn fodder per acre which was much larger than that given by the latter, the difference in yield was mainly in the amounts of water; so that the total amounts of actual nutritive material in the two varieties were nearly the same.

From the Indiana Station the following report is made as the result of tests of twenty-two varieties:

It is believed that Blount's Prolific, Golden Beauty, Piasa King, Speckled Dent, Chester County Mammoth, Maryland White Gourd, Golden Dent, and Chester County Gourd Seed would hardly mature here in an average season. If a late, tall, leafy variety, with a small proportion of corn was desired for silage, Blount's Prolific, Golden Beauty, Piasa King, Speckled Dent, and Old Cabin Home would prove satisfactory. Purdue Yellow Dent, First Premium, Smedley, Pride of the North, Early Yellow Hathaway, and Early Adams would doubtless mature every year in the north part of the State. The last named is, however, entirely too small for Indiana. Boone County White, Duke's Early, Riley's Favorite, Leaming, and Davis's Improved would mature in favorable seasons, but would hardly be reliable north of the latitude of the Station.

At the Kansas Station more than thirty varieties of corn were tested in 1888. "Among the dent varieties, the most valuable, basing judgment on quality of grain, productiveness, and hardiness, and naming sorts in the order of merit, were: Yellow Mammoth, Leaming, Pride of the North, Murdock's, Farmer's Favorite Golden Dent, St. Charles, Queen of the Prairie, Early Yellow, Hathaway, and White Giant Normandy. Judging by the same standards, the most valuable of the early maturing flint varieties were Early Red Blazed, Longfellow, and Angel of Midnight." Though none of these equaled the best dent varieties in yield and quality of grain, the experience with corn at the Kansas Agricultural College indicates that as the result of a rich, deep, friable soil, fervent summer heats, and long growing season, the coarse (not necessarily the coarsest)

and freest growing varieties, will prove the largest yielding, the safest, and the most profitable for general cultivation. Nevertheless, farmers are recommended to plant a portion of the land devoted to corn each season with medium or small growing varieties, since these will sometimes make a crop when all other varieties fail.

As the result of tests of many varieties of silage corn at the Minnesota Station, the farmer in that State is advised to "grow those kinds of dent corn which are slightly too large to ripen but will become mature enough for silage, or will reach the 'glazing' stage. Far northward the largest flint varieties that will reach this stage can be used for silage, thus pushing the corn belt far beyond its present northern limit."

At the Pennsylvania Station the results of tests made in 1888 show "that for field crops such varieties as the Golden Beauty, Golden Dent, Smedley, and Pride of the North are the best adapted for this and the northern sections of the State. The Chester County Mammoth, Mammoth White Surprise, and White Giant Normandy may be used successfully in the southern portion as a field crop."

At the Vermont Station numerous varieties of silage corn were tested in 1888. Some of them yielded "wonderful returns." The "Red Cob" produced at the rate of 30 tons to the acre, with perfect ears a foot long. Analysis shows that several of these varieties of large corn were also of valuable quality.

ALFALFA. *

Alfalfa or lucern (*Medicago sativa*) is a forage plant resembling clover in its feeding value, habits of growth, and effects upon succeeding crops. It has been cultivated in Europe for thousands of years, and is now well known both in North and South America. In California and some of the Western and Southern States it is grown quite extensively; the production in the irrigated regions is remarkable; but for various reasons it has not been so much cultivated in the Northern and Eastern States.

Experiments by the Storrs Station have brought certain evidence that alfalfa obtains large quantities of nitrogen directly from the air; that, indeed, if plenty of mineral food is provided in the soil, it may obtain nitrogen enough from the atmosphere for very satisfactory growth. This means that alfalfa is one of the plants which the farmer may use to gather food from air, as well as soil, both for his stock and for other crops.

The New Jersey Station has experimented upon the growth of alfalfa in the field and its value as a feeding stuff and as a collector of plant food. Among the conclusions are the following:

For New Jersey it is claimed that, in comparison with red clover, alfalfa has the following advantages:

(1) It is fit for soiling purposes as early as the third week in May.
(2) It may be cut three or four times each season.
(3) The second and later growths, if harvested as soon as blossoms appear, make an excellent hay.
(4) When well rooted it successfully resists both drought and frost.
(5) Under favorable conditions it does not "run out" for many years.

Feeding value for milch cows.—To secure the best results in milk production there must be a proper balancing of the protein, carbohydrates, and fat in the ration fed

---

* Colorado Station Report, 1888, and Bulletin No. 8; Connecticut (Storrs) Station Bulletin No. 5; Iowa Station Report, 1888; Massachusetts (State) Station Report, 1888; New Jersey Station Report, 1888; New York (Geneva) Station Bulletin No. 16; Vermont Station Report, 1888.

to the cows. "Under ordinary conditions, $2\frac{1}{2}$ pounds of protein, $\frac{4}{10}$ of a pound of fat, and $12\frac{1}{2}$ pounds of carbohydrates can be profitably fed daily to a milch cow of 1,000 pounds, live weight. One ton of alfalfa hay, containing 35.3 pounds of digestible fat, 280.1 pounds of digestible protein, and 770.7 pounds of digestible carbohydrates, would furnish sufficient protein for *one hundred and twelve* days, fat for *eighty-eight* days, and carbohydrates for *sixty-one* days. Therefore, in order to feed this amount of alfalfa economically and profitably, fat sufficient for twenty-four days and carbohydrates for fifty-one days must be added from some other source. In securing these amounts of fat and carbohydrates it is impossible to avoid adding protein to a slight extent, since all farm products that are of any value for feeding purposes contain more or less protein; this addition of protein, however, may be and should be reduced to a minimum by the selection of those materials which contain in it the smallest amounts. Among these may be mentioned field corn stalks, green fodder corn or silage, wheat straw, oat straw, root-crops, etc."

The large proportion of protein (nitrogenous material) in alfalfa is very favorable, especially in feeding for milk.

"In the management of farms, either for dairy purposes or for grain farming, an excess of carbohydrates is secured which, in the great majority of cases, is wasted either through lack of proper material from other sources with which to balance the ration, or through ignorance of the real loss incurred. * * * Alfalfa, therefore, furnishes the farmers a feeding material rich in protein, which can be substituted for such waste products as wheat bran, cotton-seed meal, etc., usually bought in order to profitably utilize the excess of carbohydrates."

Alfalfa as a collector of plant food.—It is universally admitted that the mineral constituents of plants, as phosphoric acid, potash, lime, etc., are derived solely and entirely from the soil. In the case of nitrogen, however, it has long been asserted, and is now claimed to be positively proven, that certain leguminous plants, as clover, peas, alfalfa, etc., have the power of assimilating large amounts from the atmosphere when sufficient phosphoric acid, potash, and lime are present in the soil.

Therefore, while it is quite possible that alfalfa, being a deep-rooting plant, could secure all this nitrogen from the soil, the probability that it has secured a large quantity from the air enhances its value as an agricultural plant, firstly, because nitrogen is the basis of the compound protein, the most valuable part of the food product, and secondly, because nitrogen is the most costly element in fertilizing compounds.

Alfalfa serves, therefore, not only as a manufacturer of the chief element of food, but also as a collector from sources otherwise inaccessible of the most valuable fertilizing agent for a large class of agricultural plants whose only source of nitrogen is in the soil. It acts in the hands of the farmer as an agent for rendering locked-up capital available.

When alfalfa is grown and its products are properly utilized upon the farm it can not be considered an exhaustive crop, but rather as one fulfilling the proper aim of rational agriculture, which is to transform into produce the raw materials at our disposal in the atmosphere and soil.

The New York Station has grown alfalfa and made analyses of the hay and tested its digestibility by experiments in which it was fed to cows. The results lead to the conclusions—

(1) That lucern or alfalfa may be successfully grown in New York State.

(2) That when once established it thrives well upon clay land, but will probably do better upon good light loam.

(3) That seed two years old loses its vitality and fails to germinate. Undoubtedly many of the failures to secure a stand of plants may be traced to poor seed.

(4) That the seed bed must be well prepared, and, in this latitude, it seems best to plant out the seed in the spring, and with no other crop. The seed should be but lightly covered by rolling the ground.

(5) That for seven successive years at the Station three and four cuttings per year have been taken from the plats.

(6) That last year, the sixth in succession, the plats yielded more than 15 tons per acre of green forage, equal to 5.6 tons of alfalfa hay.

(7) That alfalfa should be cut in early bloom, before the plants become woody.

(8) That it should be cured largely in the cock to produce the best quality of hay.

(9) That by chemical analysis the hay was found to be more nitrogenous than good red clover.

(10) That cattle, sheep, and horses all relished the hay and seemed to do well.

(11) That it was found to be more digestible than red clover hay.

(12) That if farmers would try this crop we advise them to begin with a small piece of well-prepared land in order to see whether alfalfa does as well with them as it has at the Station.

(13) That probably success with alfalfa will depend largely upon having fresh seed, a good, carefully prepared seed bed, and in covering the seed lightly with soil.

The Colorado Station has also experimented upon the growth, composition, and digestibility of alfalfa, and gives the following reasons for believing that it is an excellent forage plant for that State and for the whole arid region of the West:

(1) It is easy to raise and secure a fine stand of plants if the soil be put in proper condition.

(2) Its staying qualities are good, as the oldest fields show no diminution in growth or yield; neither does it kill by winter exposure if given the least care and irrigation at the proper time.

(3) The quantity produced by the many cuttings makes it much more valuable than the other clovers or grasses.

(4) It is as digestible as clover hay, constituent by constituent.

(5) Its chemical composition shows that it is a rich, strong food when properly cured.

(6) Its feeding qualities are excellent, being relished by all farm animals.

It is also an excellent flesh and milk producer. In general, it will do to say that it has about all the good qualities of a forage plant, with very few poor ones.

On the other hand, the Vermont Station instituted a large number of tests by farmers to whom it supplied seed and directions for experiments, and reports that—

Alfalfa was tried on over thirty farms throughout the State, and although it did well the first summer and was looking finely when the snow came, in most cases it winter-killed, and the almost unanimous opinion of those who tried it was that it was not adapted to our climate.

In brief, the experience of the stations indicates that alfalfa is a plant valuable for fodder, and as a collector of nitrogen from the air and of that and other elements from the soil, but that it requires peculiar conditions of climate and soil for growth, and careful culture and curing to make it a profitable crop. A plant so valuable is worthy of repeated and systematic experimental tests by farmers, even though in some regions and on some farms it should prove a failure.

SILOS AND SILAGE.*

Location and construction of the silo.—The Kansas, Ohio, and other stations have given especial attention to these details. They advise that the silo be as near the feeding place as practicable and on the same level. If, as is very often the case, the herd is fed in a long shed or barn where the animals stand in stanchions in two long rows

* Illinois Station Report, 1888; Kansas Station Bulletin No. 6; Maryland Station Report, 1888; Michigan Station Bulletin No. 47; Minnesota Station Bulletin No. 7; Mississippi Station Bulletin No. 8; Missouri Station Bulletins Nos. 7 and 8; New Hampshire Station Report, 1888; New York (Geneva) Station Bulletin No. 16; Ohio Station Bulletin, Vol. II, No. 3; Texas Station Bulletin No. 6; Wisconsin Station Report, 1888, and Bulletin No. 19.

facing each other, with an alley between, the best location for the silo is at one end of the building with the door of the silo opening opposite the common alley. A root cellar already constructed near the feeding place may in some instances be economically converted into a silo, or a bank silo may be used, provided it is so arranged that the silage can be withdrawn at the lowest point. Experience seems to show that wood is the best material for silos. Brick or stone is much more expensive, and the results obtained where either has been used have been much less reliable than with wood. Portions of stone walls belonging to cellars or foundations of barns may, however, be utilized by covering them on the inside with wood. The method of construction, which on the whole is to be recommended, is in general terms as follows: On a light foundation of stone set up a strong frame-work of studding (2 by 8 to 12-inch stuff). On the outside of this frame put a layer of stock boards and on the inside two thicknesses of matched boards with tarred paper between. The outside may also be battened and painted, though this is not necessary. A tight roof should be added. A dry and hard dirt floor will answer every purpose. The size of the silo should be proportioned to the number of cattle to be fed. It is better to have it too large than too small. A cubic foot of silage (about 40 pounds) per day per animal seems to be a sufficiently accurate calculation on which to base the size of a silo. From 12 to 15 by 13 to 18 feet, and 22 to 24 feet deep, are common dimensions for ordinary silos. If built much larger they should be divided by a partition. It is probably better not to mix two kinds of crops in the same compartment. That silage may be well preserved the silo should be perfectly air-tight, and strong enough to resist the great lateral pressure which results from compressing tons of material within a deep box. An experiment at the Kansas Station with a silo 13 by 18 feet and 21 feet deep showed the lateral pressure of the silage to be about 55 pounds per square foot when the filling of the silo was completed. For about two weeks thereafter there was a small daily decrease in this pressure.

Silage has been successfully fed to a great variety of animals under different conditions and is considered by many experimenters and farmers a valuable substitute for dry fodder or roots. It seems specially adapted to cattle, but is also fed with good results to horses, swine, and poultry. "Silage," says Professor Johnson, of the Michigan Station, "is excellent food for dairy cows, producing milk of the best quality." From experiments at the Wisconsin Station the conclusion was drawn "that dairy cows readily consume a sufficient quantity of corn silage to maintain a flow of milk and yield of butter fully equal to and rather more than that produced by feeding dry fodder corn." Besides its other advantages an important consideration is that a larger amount of food can be stored in a given space if silage is substituted for dry fodder. The idea that the small farmer can not afford the silo is strongly controverted by Professor Johnson. "I believe if the farmer with few acres looks at this question rightly he will find the silo an essential adjunct to his farm dependencies quite as much, aye, more than the large land owner. The small farmer with limited area of land is necessitated to crop more continuously than his neighbor with a much larger acreage. He needs in every possible way to secure the fertilizing material that shall replace the drains that this closer cropping is making on his fields. How can he do it so cheaply,

so surely, as by growing large crops of silage corn that will give him the main fodder necessary to enable him to feed for the market or the dairy through the winter much more stock than his acres will carry in the summer?" In a recent experiment in Kansas "the actual cost of cutting up the corn, hauling it 50 rods to the silo and storing it therein, was 62 cents per ton. This includes fuel for the engine, but no charge is made for the use of machinery." Professor Shelton, under whose direction the experiment was made, has no doubt that this expense might be greatly reduced. Silage is not a complete ration but should be fed in connection with some hay or other dry fodder and grain, oil meal, cotton-seed meal, wheat bran, or other nitrogenous food. This follows from the fact that silage contains an excess of carbohydrates or fat-forming materials and should therefore be combined with feeds containing more nitrogen to form a well balanced ration.

Silage alone may, however, in some cases, produce better results with less expense than could be obtained with hay as an exclusive diet. Mr. Hickman, of the Ohio Station, for example, fed a dozen heifers about two months in the winter on silage alone, giving them 40 to 50 pounds apiece per day in evening and morning feeds, at a cost of $1.75 per head per month, or little more than half as much as hay would have cost for the same period. "After they had been eating silage four or five weeks they began to shed their winter coats—it was then the middle of March,—and at the end of eight weeks they had lost most of their winter hair, and gave every indication in appearance of having been running upon pasture. The heifers were not weighed during this experiment, but their appearance at its conclusion was such as to convince practical feeders that they had done better than they could have done on hay alone."

It is generally agreed that corn is the best crop for silage in this country. Dent varieties are preferred in most cases, though Southern or silage varieties are recommended by some experimenters because of the large yields they give, and in the extreme North certain of the flint varieties may be used to the best advantage. In some localities, as in Kansas and other Southern States, sorghum is a very important crop for silage. The Kansas Station recommends medium-growing saccharine and the non-saccharine varieties for silage and especially Golden-Rod, Late Orange, and Goose Neck. The sorghums have some advantages over corn. "They are less liable to damage by insects and they remain green far into the fall, usually until cut by frosts, so that the work of filling the silo may be carried on long after the corn plant has ripened its crop and the stalks have become worthless."

Clover, alfalfa, cow-peas, and other forage plants have been successfully used for silage, but corn and sorghum will undoubtedly continue to be the principal crops used for this purpose. Corn for silage should be planted early enough in the season to secure the proper maturity. The time of planting will vary from May 10 to June 15, according to locality, season, and variety of corn. The seed should be planted in drills 3 to 3½ feet apart. The Ohio Station advises that about twelve quarts of seed per acre should be used in most cases, though with some of the larger Southern varieties fifteen quarts may be necessary. There is still considerable variety of opinion as to the proper time for harvesting the crop, though the recent investigations seem to favor greater maturity than was formerly thought desirable. Chemical analyses recently made at the New

York State Station indicate "that for the greatest amount of nutriment, considered from a chemical stand-point, corn should not be cut before it has reached the milk stage of the kernel." In Ohio it is recommended that "fodder corn should be cut when the corn begins to glaze and when the stalks begin to dry near the ground." But in Kansas, where the intense heat and other special climatic influences hasten the ripening of the crop, it is thought that harvesting "should not be delayed after the corn is in the early dough state." For hauling fodder corn to the silo any low-wheeled wagon is convenient, but if such a vehicle is not at hand a temporary rig* can be made by taking 2 by 8 joists, 16 feet long, fastening one end of each to the front bolster, the other ends passing under the rear axle, to which they are securely chained or bolted. Before putting on these joists the wagon will need to be coupled out at least 14 feet. Three or four cross-pieces may be bolted on these 2 by 8 joists, and boards are then laid upon these cross-pieces.

It is now quite generally thought better to put both stalks and ears in the silo than to use the stalks alone for silage. Before being placed in the silo the corn should be cut into small pieces. Some experimenters prefer one-half-inch lengths as these will pack more evenly and solidly than longer pieces. It is a good practice to keep a man in the silo while it is being filled to see that the silage is packed as closely in the corners and along the sides as elsewhere. If the filling occupies much time so that the silage becomes heated, some of the heated silage near the sides should be from time to time thrown into the center and replaced with the warmest silage so as to keep the temperature of the whole mass as even as possible. It seems to make little difference whether the filling is continuous or extended over several days, provided the work is carefully and thoroughly done. There is no agreement among experimenters as to the necessity of weighting the silo. At the Ohio Station a wooden cover made of flooring boards well fitted together was placed on the silo. On this was placed about a ton of sand in boxes, and around the edge of the cover next the silo walls a piece of inverted sod to prevent the entrance of air. After the silage had settled about 2 feet a ton of grass was thrown over the boxes of sand. In Kansas a layer of tarred paper, covered about 18 inches deep with green grass, has been as effectual as weighting heavily with rocks. Professor Johnson, of Michigan, thinks that a covering of hay or straw may be safely used, but that it will often be fully as economical to put on a moderate weight of other materials.

EXPERIMENTS IN SWINE FEEDING.

The enormous importance of the swine-growing interests of the country, and the pressing need of more accurate information as to how to feed swine most economically and profitably have led to a large amount of experimenting on this subject by the stations. The Office of Experiment Stations is now preparing a summary of the work done in this line. The purpose is to include the details in a somewhat extended monograph, and to condense the practical results in a farmers' bulletin.

The monograph will contain accounts of experiments made by twelve agricultural colleges and experiment stations, in as many

* For illustrations of this vehicle see Wisconsin Station Bulletin No. 19, or Ohio Station Bulletin, Vol. II, No. 3.

States, two farmers' clubs, and several individual farmers. Among the experimenters are Professors Miles, of the Michigan, and Farrington, of the Maine Agricultural College; and Goessman, of the Massachusetts; Sanborn, of the Missouri; Henry, of the Wisconsin; Shelton, of the Kansas, and Jordan, of the Maine Experiment Station. The investigations have been conducted by seventeen experimenters and several times as many assistants. The total number of experiments reported is one hundred and ninety, made upon thirteen hundred and fifty animals of various ages and breeds.

Comparisons of different breeds of swine were made by six observers in fifteen experiments.

Sixteen different feeding stuffs were used in these experiments, either alone or in various combinations. Corn meal appears to have been the most popular feeding stuff, having been employed, either by itself or in combination with other feeds, by fifteen experimenters in ninety-seven experiments. Whole corn was used by twelve experimenters in forty experiments, and corn-and-cob meal by seven experimenters in thirteen different experiments. Milling products of various kinds, bran, shorts, middlings, etc., were used by eight experimenters in fifty-two experiments. Skim-milk stands next in order, having been used by seven experimenters in thirty-four experiments. Among the fodders less frequently used were oats, peas, gluten meal, cotton-seed meal, oil meal, sorghum-seed meal, roots, buttermilk, and dried blood. The effect of grinding feed upon its value was studied by seven experimenters in eleven experiments. The effect of adding nitrogenous feeds, shorts, peas, gluten meal, dried blood, skim-milk, etc., to rations composed largely of feeds deficient in nitrogen, like corn meal, was studied by six investigators in nineteen experiments. The effect of cooking feed upon its nutritive value was investigated by eight experimenters in twenty-one experiments.

The effect of the feed upon the proportion of fat and lean in the carcass was studied by five experimenters in eleven experiments. The effect of exposure to cold and of insufficient protection of the animals was the subject of three experiments by three different investigators. Other subjects experimented upon were maintenance feeding, *i. e.* quantity of food required to keep the animal without gain or loss in weight, the importance of the ash ingredients of the food, the effect of wetting the food, and the effect of insufficient food.

Besides throwing light upon these questions the results recorded in the monograph furnish data upon others which were not made the subjects of specific experiments, such as the effect of the same food upon animals at different ages and of different weights, the effect of the quantity of food eaten per day upon the results of feeding, and the influence of the proportion of nitrogenous and non-nitrogenous matters in the food, *i. e.* what is called the nutritive ratio.

The results obtained from so large an amount of careful experimenting of course can not be given in detail here, but the following may be noted as of special interest and practical value:

Raw vs. cooked feed.—Twenty-one different experiments were made upon the relative value of cooked and raw feed. In almost every instance the absolute gain in live weight and the gain in weight per pound of feed consumed was greater from the raw than from the cooked feed. It is to be noted, however, that in the majority of cases the animals ate more of the raw than the cooked feed, and this is probably in part the explanation of the greater apparent value of the former. But it seems questionable whether this fact explains the

whole difference, since it likewise appears in those experiments where as much cooked as raw feed was eaten. On the whole it appears certain that so far as the effect of the feed is shown by increase in weight, cooking was of no advantage in these experiments, and probably was distinctly disadvantageous even after allowance is made for the smaller amount of cooked feed consumed. It should be noted that in most of these experiments the cooked feed was fed cold, in other words, the test was a test of *cooked* feed and not of *warm* feed.

Grinding feed.—Eleven experiments were made upon this subject, the results of which vary considerably among themselves, owing in part, no doubt, to the very variable quantities of feed eaten; in some cases a large excess of unground feed being consumed, and in other cases a large excess of ground feed. On the whole the indications are against grinding. Taking the results of these experiments in conjunction with those upon cooking just referred to, it would seem that for healthy fattening of swine there is no advantage to be gained by preparation of the feed, but that the slow eating and thorough chewing of the feed necessary when it is fed dry are a distinct advantage.

Exposure.—Three different experiments show that a very considerable loss is incurred by exposing swine to severe weather without shelter. In these experiments from 10 to 20 per cent more of the fuel value of the feed, according as the weather was more or less severe, was diverted from the productive purpose and used to keep the animals warm.

Feeding for fat and for lean.—Five series of experiments are reported upon the effect of the composition of feed upon the composition of the body, the relative weights of the different organs, and of fat and lean in the meat. Three of these experiments were with young animals, and showed that with these animals nitrogenous rations (shorts, bran, skim-milk, pea meal, etc.) made stronger bones, a greater proportion of lean meat to fat, and better developed internal organs (kidney, liver, etc.), than carbonaceous feed, such as corn meal. The remaining two experiments were with mature animals. One of them made upon ten animals showed no advantage as regards strength of bones, proportion of lean meat, or development of internal organs, arising from the use of nitrogenous food, but on the other hand, a distinct advantage from corn feeding, because of shorter time required for full ripening by the animals receiving corn only as compared with those fed with the nitrogenous food. The other experiment was made upon one animal, and showed a very considerable increase of lean meat in the carcass as a result of feeding a highly nitrogenous ration.

Influence of age and weight of animals upon their utilizing of feed.—The experiments brought together in this bulletin will furnish a large mass of data upon this subject, and show beyond question that the amount of feed eaten per 100 pounds of live weight decreases, and that the number of pounds of feed required to produce a pound of gain increases with the age and weight of the animals, and that as the animal approaches maturity this change goes on with increasing rapidity. They demonstrate in a striking manner the fact that for producing cheap pork it is essential to use young and growing animals and to stop the fattening process seasonably.

Pasturage.—A few experiments gave very favorable results as to rapidity and cheapness of growth in the pasture field, alfalfa in one

case proving to be an especially cheap feed. More experiments are needed in this line.

Manurial value of feed.—Such feeds as wheat bran, shorts, bean and pea meal, gluten meal, and in general, feeds rich in nitrogen, make a richer manure than corn meal, and this should be taken into consideration in estimating the value of a ration. Thus, of two feeds which will produce the same amount of pork, that one is to be preferred which gives the richer manure, especially in the older parts of the country where the soil is becoming exhausted.

Commercial relations of swine feeding.—The economy and profit of swine feeding, however, involve questions outside of the effect of the food upon the quantity and quality of the meat.

The swine grower is practically a manufacturer. Feeding stuffs are his raw material, the animal his machine, and the meat his product. Like other manufacturers he is exposed to competition. His endeavor must be to suit his product to the demand and to secure advantageous sale in home and foreign markets.

The principal use of his product is for food for man. The relative amount of pork products, *e. g.* lard oil used for manufacturing, is very small; and unfortunately pork as now produced is getting to be more or less unsuitable for the food market and the competition of other products, both for food and for other purposes, is increasingly severe.

The larger part of our pork is made from corn. Corn is deficient in the nitrogen compounds which are called protein and which make blood and bone, muscle and tendon. Pork made from corn exclusively has relatively little lean. The corn fed pork in the market is mostly fat. To make it leaner feeding stuffs rich in protein, such as milk, bran, shorts, peas, beans, and clover should be used.

The fat of pork, when used for food, serves for fuel to keep the body warm and yield muscular energy and strength for work. The fat of beef, mutton, and other meats, and the oils, as cotton-seed and olive oils, serve the same general purpose in nutrition as the fat of pork. Sugar, and likewise the starch of wheat, corn, and other grains that make up a large part of the food of mankind, also serve for fuel and thus perform the same service in nutrition as the fats.

American meats, including beef and mutton as well as pork, are very fat. This is a natural result of the conversion of the grasses of the western ranches and the grass and corn of both the West and the East into meat, and the tendency to condense the raw material in the manufactured products. Cotton-seed oil is largely used for food. The consumption of sugar has increased until it has become immense. Moreover, the demand for animal and vegetable fats and oils for other uses than as food is interfered with by petroleum and its products, which have come into general use for illuminating and manufacturing purposes.

Late studies of the food and diet of the people in this country have revealed the fact that the amounts of fat and of sugar consumed are very large. This comes from the abundance and fatness of the meats and the increased supply of sugar. Indeed, our national dietary appears to have become one-sided, so great is the excess of fuel material. A reaction, however, seems to have begun. Sellers of meat in many places are finding a decrease in the demand for fat meat, and large amounts of fat are rejected by customers in the butchers' shops, in the trimmings of beef for instance, and by consumers of meat after it is cooked, as may be noted by any one who observes the plates re-

moved from family and hotel tables. This apparent decrease in the demand for fat meat seems to be in response to an instinctive tendency to shape the diet more or less to the actual demands of the body.

On the other hand pork is needed across the Atlantic. The working classes of France, Germany, and other countries of Europe are under-fed. They lack meat, and with the rest, the fat which we have in excess. This fact is already appreciated by the physiologists of these countries whose opinion is accepted as authoritative. The restrictions placed upon the importation of American pork, however, hinder its sale there. A valuable service would be rendered to the producers in the United States and the consumers in Europe if this subject could be studied thoroughly and the facts brought out in detail for the education of public opinion and for their influence upon legislation.

In brief, the pork producer in this country has come to be essentially a manufacturer of fat. Like other manufacturers he must compete in the markets of the world, home and foreign. He meets serious competition in the fat of other meats, in cotton-seed oil, in sugar, and in petroleum. The home market is relatively overstocked with fat pork. There is demand for it in the foreign markets, but the restrictions placed upon the importation of American pork hinder his access to them.

There are, then, two things for the pork producer to do: make leaner pork and get better access to foreign markets. Leaner pork can be obtained by the use of nitrogenous foods, skim-milk, bran, shorts, cotton-seed meal if it can be advantageously utilized, beans, peas, clover, alfalfa, and other leguminous plants. It is, however, impracticable for many pork producers to change their system of feeding at once. The bulk of the pork of the country is and for some time must be manufactured from corn, but where nitrogenous foods are available they should be used, and where they are not available the attempt should be made to introduce them. Here is a strong reason for experiments with leguminous forage plants; besides helping to make leaner pork they have the advantage that with them poor hay, straw, and corn stalks can be utilized and that they make rich manure.

To facilitate access to foreign markets, the facts regarding the need and value of our American products must be brought out clearly. Of course this will require much research; the process must be slow and no one can positively predict the results. But it is at any rate safe to say that the facts now at hand are such as to promise an argument of the strongest character.

COTTON-SEED HULLS AND MEAL AS FEEDING STUFFS

A recent bulletin of the Tennessee Station* gave the results of an investigation of cotton-seed hulls and meal as food for live stock. The conclusions reached were very interesting. It was found that the practice of feeding cotton-seed hulls and meal as an exclusive diet was well established in the vicinity of oil mills. Everything indicated that the practice was both economical and profitable. A daily ration of from 25 to 35 pounds of hulls and 5 to 8 pounds of the meal could apparently be fed continuously without any risk. The hulls thus seem to be a cheap and effective substitute for hay, which

* Tennessee Station Bulletin, Vol. II, No. 3.

may prove of the greatest value in a cotton-raising country, and help to remove the obstacles which so largely prevent the cotton planter from growing live stock. The manure resulting from this system of feeding was found to be uncommonly rich, and thus becomes a most important factor in making this ration profitable, since the cotton planter, in at least a majority of the Southern States, is in constant need of fertilizers.

It should be observed, however, that such questions as the effect of relatively large rations of cotton-seed meal upon the quality of the pork, beef, or butter produced, still remain to be investigated.

BETTER COWS FOR THE DAIRY.

The need of better cows for the dairy is coming to be very generally appreciated. The dairy commissioner of Iowa is reported as saying that the average cow in that State gives but 3,000 pounds of milk annually, while good ones yield from 5,000 to 6,000 pounds. The director of the Vermont Station is credited with the statement that the average yield per cow in that State is only 130 pounds of butter per annum, while there are thirty dairies in the State that average over 300 pounds per cow.

The differences in the milk-producing qualities of different cows are brought out very clearly by a series of experiments conducted at the Massachusetts State Station, of which Prof. C. A. Goessman is director.* They are especially interesting because the cows and their feed and care were such as are found on the better farms of Massachusetts, and the results obtained with the appliances of a well-equipped experiment station show in accurate and full detail the elements of actual profit and loss as they could not be found in ordinary farm experience.

These experiments have been made with twelve cows and have continued over five years. Grade Jersey, Ayrshire, Devon, Durham, Dutch and native cows were used. They were secured for the experiments a few days after calving and fed until the daily yield fell below 5 or 6 quarts, when they were sold to the butcher. The length of the feeding period, *i. e.* duration of the experiment with each cow, varied from two hundred and sixty-one to five hundred and ninety-nine days. Hay, fodder, corn, corn silage, green crops, roots, and corn meal, wheat bran, and other grain were used. The daily ration per head consisted of 18 to 20 pounds of dry fodder or its equivalent of green fodder, and from 6½ to 9¾ pounds of grain. Careful accounts have been kept of the history of each cow, including breed, age, number of calves, length of feeding period, amounts and kinds of fodder, yield of milk, chemical composition of feed, milk and manure, cost of cow and feed, and values of milk and manure.

The following is a recapitulation of the financial record of the cows:

The milk was reckoned at the price paid for it at the neighboring creameries. The value of the manure produced is calculated by assuming that of the total amount of feed 20 per cent would be sold with the milk and the remaining 80 per cent saved as manure. As farmers in the region buy commercial fertilizers for the sake of their nitrogen, phosphoric acid, and potash, it was assumed that these same ingredients would be worth about as much, pound for pound, in

*Massachusetts (State) Station Bulletins, Nos. 32 and 34.

the manure as in the better class of fertilizers, and accordingly the value of the manure was computed by taking the nitrogen as worth 16½ cents, phosphoric acid 6 cents, and potash 4¼ cents per pound. The return for feed consumed represents what the feeder receives for labor, housing of cattle, interest of capital invested, risk of loss of the animal, etc.

From the table herewith it appears that the most profitable cow was bought for $60, fed five hundred and eighty-four days, and then sold for $28, making her actual cost $32; the feed cost $135.05, so that the total cash outlay was $167.05. The milk brought $203.37 at the creamery; the manure was estimated to be worth $56.93, making the total value received for feed consumed $260.30. Subtracting the total cash outlay of $167.05 from this there remains $93.25 as total return for feed consumed. Deducting from this total return value the estimated value of the manure, the remainder, "return in excess of estimated value of manure," is $36.32. In the average for the twelve cows the total return was $50.43, and the return in excess of the estimated value of the manure only $15.13. With the least profitable cow the cash outlay for cow and feed exceeded the value of the milk and manure by $3.97. In other words, the total return for feed consumed was $3.97 less than nothing. Subtracting the value of the manure, the total loss was $34.25.

Recapitulation of financial record of cows, extremes and average.

	Most profitable cow.	Least profitable cow.	Average of twelve cows.
Period during which cows were milked .... days	584	331	402
Average yield of milk per day .... quarts	11.6	7.7	11.1
Total cost of feed consumed	$135.05	$80.08	$87.29
Estimated value of manure produced from feed consumed	56.93	30.28	35.30
Difference, net cost of feed consumed	78.12	49.80	51.99
Receipts from milk sold at 3 cents per quart	203.37	75.83	135.91
Estimated value of manure produced from feed	56.93	30.28	35.30
Sum, total value received from feed consumed	260.30	106.11	171.21
Cash paid for cow at beginning of milking period	60.00	55.20	62.29
Cash received for cow at end of milking period	28.00	25.00	28.80
Difference, actual cost of cow	32.00	30.20	33.49
Actual cost of cow	32.00	30.00	33.49
Total cost of feed consumed	135.05	80.08	87.29
Sum, total cash outlay	167.05	110.08	120.78
Total value (milk and manure) received for feed consumed	260.30	106.11	171.21
Total cash outlay	167.05	110.08	120.78
Difference, total return for feed consumed	93.25	−3.97	50.43
Total return for feed consumed	93.25	−3.97	50.43
Estimated value of manure produced from feed	56.93	30.28	35.30
Difference, return in excess of estimated value of manure	36.32	−34.25	15.13

That is to say, allowing for the value of the manure, the results with the twelve cows varied from a *gain* of $93.25 to a *loss* of $3.97; or, if the value of the manure be left out of account, from a *gain* of $36.32 to a *loss* of $34.25.

It is noticeable that the profit or loss did not depend upon either

the breed or the length of the feeding period. The most profitable cow and the least profitable but one were both of the same breed. Of the two most profitable cows, one was fed for five hundred and eighty-four and the other for only two hundred and seventy-eight days.

Two things, then, are brought out very clearly by these experiments. One is that in such localities as this the value of the manure goes far to decide the profit in feeding dairy cattle. Another is that cows which would ordinarily pass for good ones may differ widely in product.

To the practical dairyman these experiments teach clearly the difference between cows which are profitable and those which are not, and the importance of selecting the best cows for his dairy and getting rid of the poor ones. In a larger sense they illustrate to every farmer the importance of knowing accurately the condition of his business. Upon this its success or failure largely depends.

DAIRYING.*

Besides the feeding experiments with milch cows already referred to, a considerable number of the stations have made investigations on subjects relating to dairying. These include analyses of milk, butter, and cheese; tests of dairy apparatus; the devising of methods for testing milk, especially with reference to the determination of butter fat; trials of different methods of creaming and butter making, and the investigation of creameries with reference to their improvement or introduction into communities where they are now practically unknown. Among the more scientific investigations of the nature of milk and the causes of the changes in milk and its products may be mentioned those of Dr. Babcock, of the Wisconsin Station, who has announced the discovery of fibrin in milk, and those relating to the nature and action of the bacteria of milk by Professor Conn, for the Connecticut (Storrs) Station.

BUTTER MAKING.

With regard to butter making the Texas Station† has published the following practical advice, some of which is especially adapted to the Southern States:

(1) Cows should have an abundance of good food and water.

(2) Handle the cows quietly and carefully.

(3) Salt regularly, at least once a week—twice is better—or place lump salt where they can have access to it.

(4) Milk regularly and don't let the milk stand where it can absorb odors from the stable or barn-yard.

(5) When the centrifugal is used, the best results will be obtained by separating at about 80° to 85° F. When the centrifugal is not used, if there is a cold spring or well-water at hand, set the milk in deep cans, not over 6 or 7 inches in diameter,

---

* Alabama College Station Bulletin No. 7; Colorado Station Report, 1888; Connecticut State Station Report, 1888; Connecticut (Storrs) Station Bulletin No. 4; Indiana Station Report, 1888; Iowa Station Report, 1888; Maryland Station Report, 1888; Massachusetts State Station Report, 1888; Minnesota Station Bulletin No. 7; Mississippi Station Report, 1888; New Hampshire Station Report, 1888, and Bulletin No. 7; New York (Geneva) Station Report, 1888; New York (Cornell) Station Report, 1888, and Bulletin No. 5; North Carolina Station Report, 1888; Texas Station Bulletin No. 5; Vermont Station Report, 1888, and Bulletins Nos. 16 and 17; West Virginia Station Report, 1888, and Bulletin No. 4; Wisconsin Station Report, 1888, and Bulletin No. 18.

† Texas Station Bulletin No. 5.

in water to a depth equal to the depth of the milk in the cans. When cold water can not be obtained, set the milk in shallow pans 4 or 5 inches deep in a well-made cellar.

(6) Skimming should take place after eighteen to twenty-four hours in summer and twenty-four to thirty-six hours in winter.

(7) Churn when the cream is nicely acid but not too sour.

(8) The best temperature for churning in this latitude has been found to be 63° to 65° in summer and 69° to 70° in winter. Determine temperature with thermometer.

(9) All vessels should be made scrupulously clean. Use hot water always, and if greasy, use washing soda.

(10) Use the best quality of dairy salt.

CREAMERIES.

The establishment of creameries is a question of great importance, especially in some of the Southern States. The West Virginia Station has made a strong appeal to the farmers of that State to attempt dairying and support creameries, and has given in a late bulletin directions for building and operating a creamery. In Texas the Station has illustrated the advantage of creameries by carrying on one since June, 1888. A recent bulletin gives detailed plans and specifications of a creamery with a capacity of 200 to 250 pounds of butter daily, and costing from $2,500 to $3,000. Such changes in the construction of the creamery as a careful study of those in successful operation in other Southern States has shown to be advisable are recommended. The Mississippi Station has been working in the same direction.

SEED TESTING.†

Reports on this subject have been received from eight of the stations. The farmer needs to select seeds that are free from impurities and will germinate, and to use enough but avoid waste in sowing. The principal difficulties with the seeds commonly sold in the markets are impurities and lack of vitality. The impurities include not only dirt, which does little harm, but also seeds of weeds and parasitic plants, some of which are very harmful. As regards vitality, the main thing is the power to germinate, or in farmers' language to "sprout." The vigor for sprouting is often injured or destroyed by age, frost, disease or decay. Often there is great waste in sowing. Much attention has been given to these matters in Europe and great benefit has resulted. Thus far comparatively little has been done in this country toward exercising any control over the seeds sold in the several States, and the farmers are not thoroughly aroused to the importance of the subject. Stations should not only make tests to detect imperfections and impurities in seed, but they should also point out to the farmer the dangers which lurk in the seeds he buys or grows, and which may easily escape his observation, and should show him the desirability of systematic efforts to secure good seeds and explain to him how to better economize in sowing.

The tests of the seeds of garden vegetables thus far made in this country have as a rule borne testimony to the honesty of American seedsmen. Professor Chester, botanist of the Delaware Station, from the results of examinations of a large number of varieties of these seeds as sold in that State, reports that "garden vegetables, in ac-

* Mississippi Station Report, 1888; Texas Station Bulletin No. 5; West Virginia Station Bulletin No. 4.

† Colorado Station Report, 1888; Connecticut State Station Report, 1888; Maine Station Report, 1888; North Carolina Station Report, 1888, and Bulletins Nos. 59, 61½, 63, and 67; South Carolina Station Report, 1888; Delaware Station Bulletin No. 5; Pennsylvania Station Bulletin No. 8; New York (Cornell) Station Bulletin No. 7.

cordance with experience elsewhere, give a high percentage of purity and are comparatively free from weed seeds." Prof. L. H. Bailey, of the New York (Cornell University) Station, also says, as the result of his experience, that "there appears to be no pernicious adulteration of garden seeds in this country, and as a rule there are no hurtful impurities." Exceptions to this general rule, however, indicate that the farmers should be very careful to deal only with responsible parties, and especially to make sure that the vegetable seeds sold by retail dealers are fresh.

With regard to grasses, clovers, and other forage plants, the tests made at the stations indicate a much worse state of things, both as regards the number and quantity of impurities and the vitality of the seeds. Farmers need to be very careful in selecting the seed of grasses and other forage plants, and organized precautions against the sale of impure seeds seem to be highly desirable. The following facts are cited by the Delaware Station from its own observation and from experience elsewhere:

Kinds of impurities.—In one hundred and forty-eight samples of seeds of grasses and forage plants sold in Delaware, forty-four contained plantain (*Plantago major*); twenty-seven, sheep-sorrel (*Rumex acetosella*); twenty-five, rag-weed (*Ambrosia artemisiæfolia*); five, dodder (*Cuscuta*); and one, Canada thistle (*Cnicus arvensis*). Twenty-six different species of weeds were found in the samples tested. "This list tells its own story as to how the majority of weed seeds get upon the farm, for not only is the farmer sowing them, but, as Ledoux has remarked, he is sowing them upon well-prepared land, where they will be sure to grow."

Quantity of impurities.—One sample of red clover seed contained 9.2 per cent of impurities. These were seeds of nine kinds of weeds, etc., among which were plantain, smart-weed, rag-weed, and foxtail grass. Taking 8 pounds of this clover seed, the usual quantity for an acre, the number of weed seeds was sufficient to give one seed of sheep-sorrel every 4 feet in drills 3 feet apart; one of rag-weed every 10 feet in drills 6 feet apart, the same number of dodder and enough of all the weed seeds of different kinds to make one seed every 6 inches in drills 9 inches apart. Another sample which came nearer the average, had 1.2 per cent of impurities by weight. If 8 pounds of this seed were sown on an acre the number of weed seeds would be sufficient for one every foot in drills 15 inches apart.

The tables of purity and vitality of seeds given in the bulletin show how it is possible, even by the use of a comparatively pure seed, to introduce upon land a supply of weeds which may in time overrun a farm to a serious degree, and when we consider that this process of sowing weed seeds is repeated from year to year the argument has still greater force.

A striking instance of the need of precautions in this country is given in a sample of alfalfa seed sent to the Delaware Station for examination.

The purchaser remarked that it was one of the purest seeds he had ever seen, and an examination proved this fact, the proportion of impurities being only four-tenths of 1 per cent, mainly dirt. But a close examination revealed the presence of *Cuscuta*, or dodder seed, at the rate of seven hundred and twenty to the pound. This seed when sown at the rate of 15 pounds to the acre, which is about one-half that generally sown in Germany, would furnish nearly eleven thousand *Cuscuta* seed to the acre, or enough to give one seed every 2 feet in drills 2 feet apart. The sowing of this much *Cuscuta* seed upon an acre of land would, at the least, be a dangerous procedure, and might result in a total destruction of a crop in the course of two or three years.

Every precaution is to be taken against the introduction of this parasite into the State. In Germany its presence has proved a national calamity, and well-nigh forced German farmers to abandon the growth of clover.

The flax dodder, according to Ledoux, broke up the culture of flax in North Carolina and paved the way to cotton culture. In Germany the fight against the *Cuscuta* has been vigorous, but the enforcement of stringent laws and the sharp eye kept by the German seed controls over the quality of clover and alfalfa seed has done much to reduce this evil.

In order to improve seed testing, if possible, by more thorough and accurate methods, investigations have recently been made at the Cornell Station which indicate that conditions of temperature, moisture, light, and latitude have much to do with the results of seed tests; that germination tests should be made in soil as well as in germination apparatus; that tests should be duplicated; that, owing to the many accidental circumstances connected with planting in the field, the results there can not be considered a true measure of the value of any particular sample of seed, and that rapidity of sprouting, unless under identical conditions, is not a true measure of vitality or vigor of seeds.

Prof. G. McCarthy, of the North Carolina Station, concludes, from a considerable number of tests of seeds of clover, grass, and other forage plants, that—

(1) Grass and clover seeds deteriorate very rapidly with age, and generally are not worth sowing after they are two years old.

(2) Aged and deteriorated seeds are often sold by local store-keepers.

(3) Farmers should test samples before purchasing seeds, and purchase directly from some reliable seed grower, or from a local merchant who will guarantee the quality of his seeds.

In germination tests of seeds found on sale in Maine, Professor Harvey, of the station in that State, finds a very wide range in the "per cent sprouted." In discussing tables of the report in which the results of his tests are summarized, he says:

By comparing the grasses one will see that in the more common kinds, for instance Timothy, the per cent germinated is high, 88 to 95, while in those rarely sown it is low. This is easily explained, as seed for which there is but a slight demand would remain on sale for a long time, so that the greater the demand the newer the seed. This is a good illustration of the difference between new and old seed, as the per cent sprouted varies from 96 to 0, and from the more common to the less common kinds. The clovers show a high per cent of germination throughout, some of them sprouting 95 per cent in twenty-four hours from the time they were put in the germinator. In studying the tables notice the number of days before the seeds began to sprout, as rapid sprouting shows high vitality. The conclusions we draw from these experiments put into rules to aid in purchasing seed would be:

See that the seeds look new and fresh; notice whether they are plump or shriveled, and whether or not they are uniform in size. If some are large and some are small, only the former will grow. Also, see that they are free from foul seeds, as many troublesome weeds are introduced in this way. Buy of some reliable dealer, and continue to do so as long as the seeds are satisfactory. Buy seeds grown in our own State or from localities as far north. Farmers can easily test seeds by putting them between damp cloths or sheets of blotting paper.

HARDY FRUITS.

The Iowa Station is giving special attention to the improvement of fruits, cereals, and forage plants by cross-fertilization and careful selection of seeds from the best trees and plants. The climate of Iowa being very unfavorable to the orchard fruits of western Europe and the eastern United States, over one hundred and forty varieties of Russian apples have been tested in northern Iowa by the director of the Station during from six to fourteen years. More than fifty

varieties of these fruits seem to be adapted to the soil of this section, and able to withstand the severest droughts and coldest winters. Experimental orchards have been planted at the Station and near Cedar Falls, and experiments have been conducted in the cross-fertilization of the hardiest Russian apples with selected American winter apples, and of Russian plums with the best native plums.

THE DEHORNING OF CATTLE.*

The importance of the problem connected with the dehorning of cattle is very great in some sections of the United States. In Texas, for example, it is felt that the economical feeding of cattle must hereafter include some means for shelter, and that, therefore, it is of the greatest consequence to determine whether range cattle can be successfully dehorned, and thus economically housed. Experiments at the Station in that State indicate that this is the case. "While sawing off the horns of a full grown steer may seem severe treatment and somewhat cruel, the fact that the operation requires very little skill and time, that it is safe, that it tames the animal to a surprising degree, and that a drove of the wildest cattle may be run in a building like a flock of sheep, and that they will fatten faster after dehorning than before, leads us to believe that dehorning has solved the problem of making sheltering practicable, and that it will be adopted by the Texas cattle feeder."

In Bulletin No. 10 of the Mississippi Station, the beneficial results of dehorning are stated as follows:

> It prevents these animals from wounding and bruising and famishing one another; saves a vast amount of time in handling; of room in sheltering; and of feed stuff. Beeves are fatted for market with much less expense of feed and in less time. They go into the markets, as attested by the dealers at the great cattle depots, in much better condition, having whole hides and unbruised flesh, both of which sell more promptly and at better prices, while the cost of transportation of the live animals is much less, because a larger number can be packed in each car. For like reasons the milk, cream, and butter product is increased in quantity and improved in quality.

Reports from four other stations received during 1889 agree in asserting that, while dehorning is an operation that requires care, it is not difficult or dangerous. The wounds heal favorably, as a rule, and it is only in exceptional cases, or when the operation is improperly performed, that continued suppuration and chronic inflammation are likely to ensue and seriously interfere with the health of the animal.

Dr. Phares, in the bulletin of the Mississippi Station above referred to, especially favors the dehorning of calves, though he thinks that it "may be performed on animals of any age, with little danger of serious injury."

> At the place where the horn is to come the young calf has a small, button-like, hairless spot, easily seized and moved with thumb and fingers. After a few weeks a small tubercle may be felt under the skin; now absorption has commenced on the inside, extending from the frontal sinus, and deposit is taking place outside under the skin, and a core for the horn has commenced forming. Now is probably the best time to dehorn, and a pocket-knife or scalpel is a convenient instrument for performing the operation. The bald skin, with a border of one-fourth of an inch wide of hair-covered skin, together with cartilaginous button or tubercle beneath, may all be easily severed with a single cut and in a moment. But a few drops of blood are lost; the periosteum which secretes the bony core, and the portion of skin which secretes the horn, are removed with little pain to the calf, and in a few days it is well.

---

*Arkansas Station Report, 1888; Mississippi Station Bulletin No. 10; Tennessee Station Bulletin No. 1; Texas Station Bulletin No. 6; Wisconsin Station Report, 1888.

Prof. Plumb, of the Tennessee Station, writes as follows regarding the method of dehorning an older animal:

For removing the horns an ordinary meat saw, with a set-screw in the end of the blade furthest from the handle, that will enable the blade to be tightened, but not to turn from side to side, is perfectly satisfactory. A strong running-noose rope halter, and about 20 feet of five-eighths and 10 feet of three-eighths-inch rope are also necessary.

The horns should be removed as close to the head as possible, without cutting the skull proper. It is best to cut down from one-fourth to one-half inch of flesh at the base of the horn. The sawing should be done rapidly, and with long sweeps of the arm if possible.

The most desirable method of fastening an animal for dehorning, so as to keep it satisfactorily quiet, is to cast it, bind the feet firmly together, and hold the head in a halter, close to the ground, either by the hands, or by placing a plank across the neck. Then remove the horn uppermost, and by means of a rope of sufficient length, fastened where the feet come together, turn the animal upon the other side, and remove the remaining horn.

Dr. Phares, formerly of the Mississippi Station, on the other hand, does not approve of casting the older, stronger animals, as they are often injured in this way. He recommends the following method:

A narrow stall, with a very little labor, can be turned into a kind of stocks in which an animal may be quickly and firmly fastened by a bar across, resting on the loin or hips, another behind the hams, one touching the front of the thigh and the belly, and another against the breast. His body is thus rendered almost immovable, and it remains only to fasten the head to an immovable post in front. When the horns are removed and the stubs tarred, the animal may be released in a few seconds.

CULTIVATION OF SUGAR-CANE AND MAKING OF SUGAR IN LOUISIANA.*

Louisiana has three stations under one organization. One of these, the Sugar Experiment Station, with its head-quarters now at Audubon Park, New Orleans, is devoted especially to experiments regarding the soil, fertilizers, and methods of culture for sugar-cane, varieties of cane, and manufacture of sugar.

While in some sugar-producing regions, as Cuba, the sugar-cane is generally grown through a long series of years, each season from the stubble of the previous season, in Louisiana frequent replanting is found necessary; for this the cane itself is used. The quantity required is very large and makes an important factor of the cost of sugar production. The lower part of the stalk is richest in available sugar. If, then, the upper part of the stalk could be successfully used for planting a great saving of sugar might result. Experiments conducted through two successive seasons have indicated that the upper parts of the stalk are fully equal, if not superior, to the lower for seed. The director of the Station, Professor Stubbs, concludes that, "could a practical way be established for utilizing the upper third of the cane for seed, and grinding the remainder, an immense gain would yearly accrue to our industry."

Effects of fertilizers on sugar-cane.—"One of the chief aims of this Station is to find a fertilizer that will produce a maximum tonnage with a maximum sugar content upon the soils of Louisiana." To this end a great variety of experiments have been made to test the requirements of the soil, the forms of fertilizers especially adapted to cane, and the quantities most profitable. Materials containing nitrogen, phosphoric acid, and potash in different forms and amounts have been used. Among the conclusions are, that:

(1) Nitrogen is greatly needed by the soils of Louisiana to grow cane, as experience indicates that no one of the leading forms of nitrogen has any marked supe-

*Louisiana Stations, Bulletins Nos. 19, 20, 21, and 23.

riority over the others, and that the nitrogen in cotton-seed meal (a cheap home product) is as effective as in the costlier imported materials, like nitrate of soda, sulphate of ammonia, dried blood, etc.

(2) Excessive quantities of nitrogen have this year been but partially utilized by the crop, and "are always injurious to sugar content." The experiments of the past three years strongly suggest that from 21 to 42 pounds of nitrogen per acre (the amount found in from 300 to 600 pounds of cotton-seed meal) are all that can be profitably used. To produce the best results the nitrogen should be combined with mineral manures.

(3) The mineral manures alone are without decided effects, except on new grounds and pea-vine fallows, and even then the yields are often much improved by nitrogenous fertilizers.

(4) The phosphoric acid needed by the soils of the State is best supplied in the soluble form, as acid or superphosphate, though the insoluble forms in Charleston "floats," Orchilla and Grand Cayman guanos, seem to be available after lapses of time, depending upon the character of the soil and the fineness of the fertilizer.

(5) Excessive quantities of phosphoric acid are not economical, though they are not altogether lost. From 40 to 75 pounds per acre seem to be ordinarily the limits for profitable production.

(6) Potash in small quantities produces no apparent effects upon either tonnage or sugar content, but in excessive quantities for several years on the same soil increases the yield but not the sugar content.

The drainage of land for sugar-cane.—Experiments on the effect of tile drainage conducted for two years show a decided advantage in favor of draining such lands as those experimented upon. The average increase of yield by the tiled plats over the untiled was at the rate of 4.37 tons of cane per acre. "Besides giving a better yield of cane and sugar, the tile-drained lands are warm and mellow, so that roots penetrate more easily and deeply, and are thus better able to resist drought, while in wet weather the excess of moisture is drawn off. On these lands also the snow melts at least a week earlier on an average, and vegetation advances far more rapidly."

"Drainage is of the first importance to the sugar planter, since cane revels in well-drained land." "Tile drainage, like 'diffusion,' is surely but slowly coming."

The diffusion process for the manufacture of sugar from cane.—The same Station has made extensive tests of the diffusion process for the manufacture of sugar and published the results in one of its bulletins, giving details of manufacture and methods of clarification. Excellent results were obtained throughout. The maximum yield per ton was 240.1 pounds of commercial sugar, equal to 216.75 pounds pure sucrose per ton of cane. With the best milling applied to similar cane the quantity of commercial sugar would be from 180 to 200 pounds. The economic superiority of diffusion over milling is thus demonstrated.

At the time of this writing the diffusion process has been introduced in five or six of the largest plantations of the State.

STATISTICS OF THE STATIONS.

Experiment stations have been in operation during the year, under the act of Congress, approved March 2, 1887, in all the States except Montana, North Dakota, and Washington. In several States the United States grant is divided, so that forty-three stations in thirty-nine States are receiving money from the United States Treasury. In each of the States of Connecticut, Massachusetts, New Jersey, and New York a separate station is maintained, entirely or in part, by State funds, and in Louisiana a station for sugar experiments is maintained mainly by funds contributed by sugar planters. In many States branch or substations have been established. If branch or

substations be excluded, the number of stations in the United States is forty-six; if they be included, it is sixty-three. These stations employ three hundred and ninety-three officers, and, with this Office, expend in all about $725,000 per annum, of which they receive $600,000 from the national Treasury, the rest coming from State governments and other sources.

During the calendar year 1889 the stations have published forty-five annual reports and two hundred and thirty-seven bulletins.

The stations have made numerous changes in the personnel of the staffs during the year. Only those in the directorship can be mentioned here. Florida has elected J. P. DePass; Michigan has lost Edwin Willits, who resigned to become Assistant Secretary of Agriculture, and has elected in his place Oscar Clute; Minnesota has chosen N. W. McLain in the place of Edward D. Porter; Missouri has elected Edward D. Porter to succeed J. W. Sanborn; Nebraska has chosen L. E. Hicks to succeed C. E. Bessey; the New Jersey Stations have lost their director, George H. Cook, by death. His place is filled for the time by Merrill Edwards Gates, president of Rutgers College, with which the Stations are connected. E. M. Shelton, of the Kansas Station, resigned his position to accept one in Australia, and no successor has been appointed. George T. Fairchild, president of the Kansas State Agricultural College, with which the Station is connected, has executive charge of the Station, and I. D. Graham, secretary of the Station, has charge of the office and correspondence.

By act of the legislature the experiment Station of the University of Georgia was removed from Athens to Griffin, Ga., where it is in operation under the title of the Georgia Experiment Station, with R. J. Redding as director. The chemical work is done by special contract at the University of Georgia, but, if the present plans are carried out, will be removed to Griffin as soon as laboratories can be prepared. The connection of the Station with the University—the institution which received the benefits of the land-grant act of 1862—is constructively preserved by allowing that institution a minority representation in the governing board.

Steps have been taken in Arizona, New Mexico, and Utah to obtain appropriations from the United States government for the maintenance of experiment stations in these Territories, and a partial organization has been effected in each. These stations are located at Tucson, Ariz.; Las Cruces, N. Mex., and Logan City, Utah. Their directors are: in Arizona, S. M. Franklin; in New Mexico, Hiram Hadley, president of the agricultural college with which the Station is connected, and in Utah, J. W. Sanborn.

The legal names, locations, directors, and number of publications for 1889, *of the agricultural experiment stations in the United States.*

State.	Name of station.	Location.	Director.	Number of publications in 1889.	
				Report for 1888.	Bulletins.
Alabama	Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama. (Substations at Abbeville and Athens.)	Auburn	J. S. Newman	1	7
Alabama	Canebrake Agricultural Experiment Station	Uniontown	W. H. Newman, M. S. *a*	1	4
Arizona	Agricultural Experiment Station of the University of Arizona.	Tucson	S. M. Franklin, Ph. B	*b*0	*b*0
Arkansas	Arkansas Agricultural Experiment Station. (Substations at Newport, Pine Bluff, and Texarkana.)	Fayetteville	A. E. Menke, D. S	1	4
California	Agricultural Experiment Station of the University of California. (Substations at Cupertino, Fresno, Jackson, Mission San José, Paso Robles, and Tulare.)	Berkeley	E. W. Hilgard, Ph. D., LL. D	*c*2	3
Colorado	Agricultural Experiment Station. (Substations at Del Norte and Rocky Ford.)	Fort Collins	C. L. Ingersoll, M. S	1	4
Connecticut	Connecticut Agricultural Experiment Station	New Haven	S. W. Johnson, M. A.	*d*2	5
Connecticut	Storrs School Agricultural Experiment Station	Storrs	W. O. Atwater, Ph. D	1	3
Delaware	Delaware College Agricultural Experiment Station	Newark	A. T. Neale, Ph. D	1	3
Florida	Agricultural Experiment Station of Florida. (Substations at De Funiak, Fort Myers, and Ocala.)	Lake City	J. P. DePass	1	3
Georgia	Georgia Experiment Station	Griffin	R. J. Redding	*e*1	*e*4
Illinois	Agricultural Experiment Station of the University of Illinois.	Champaign	S. H. Peabody, Ph. D., LL. D	1	4
Indiana	Agricultural Experiment Station of Indiana	Lafayette	H. E. Stockbridge, Ph. D	1	12
Iowa	Iowa Agricultural Experiment Station	Ames	R. P. Speer	1	4
Kansas	Kansas Agricultural Experiment Station	Manhattan	G. T. Fairchild, M. A. *f*	1	4
Kentucky	Kentucky Agricultural Experiment Station	Lexington	M. A. Scovell, M. S	1	6
Louisiana	Sugar Experiment Station, No. 1	Audubon Park, New Orleans.	W. C. Stubbs, Ph. D	0	2
Louisiana	State Experiment Station, No. 2	Baton Rouge	W. C. Stubbs, Ph. D.	1	*g*2
Louisiana	North Louisiana Experiment Station, No. 3	Calhoun	W. C. Stubbs, Ph. D.	*h*1	0
Maine	Maine State College Agricultural Experiment Station	Orono	W. H. Jordan, M. S.	1	2
Maryland	Maryland Agricultural Experiment Station	Agricultural College	H. E. Alvord, C. E.	1	*i*5
Massachusetts	Hatch Experiment Station of the Massachusetts Agricultural College.	Amherst	H. H. Goodell, M. A	1	*j*17
Massachusetts	Massachusetts State Agricultural Experiment Station.	Amherst	C. A. Goessmann, Ph. D	1	4
Michigan	Experiment Station of Michigan Agricultural College	Agricultural College	O. Clute, M. S	1	13
Minnesota	Agricultural Experiment Station of the University of Minnesota.	St. Anthony Park	N. W. McLain, LL. B.	1	5
Mississippi	Mississippi Agricultural Experiment Station	Agricultural College	S. M. Tracy, M. S	1	6
Missouri	Missouri Agricultural College Experiment Station.	Columbia	E. D. Porter, Ph. D	1	5
Nebraska	Agricultural Experiment Station of Nebraska	Lincoln	L. E. Hicks, Ph. D	1	7
Nevada	Nevada Agricultural Experiment Station	Reno	S. A. Jones, Ph. D	1	4
New Hampshire	New Hampshire Agricultural Experiment Station	Hanover	G. H. Whitcher, B. S	1	4
New Jersey	New Jersey Agricultural College Experiment Station	New Brunswick	M. E. Gates, Ph. D., LL. D	1	13

New Jersey	New Jersey State Agricultural Experiment Station	New Brunswick	M. E. Gates, Ph. D., LL. D	1	7
New Mexico	Agricultural Experiment Station of New Mexico	Las Cruces	H. Hadley, M. A	*b*0	*b*0
New York	Cornell University Agricultural Experiment Station	Ithaca	I. P. Roberts, M. Agr	1	9
New York	New York Agricultural Experiment Station	Geneva	P. Collier, Ph. D	1	3
North Carolina	North Carolina Agricultural Experiment Station	Raleigh	H. B. Battle, Ph. D	1	8
Ohio	Ohio Agricultural Experiment Station	Columbus	C. E. Thorne	1	8
Oregon	Oregon Experiment Station	Corvallis	E. Grimm, B. S	0	2
Pennsylvania	The Pennsylvania State College Agricultural Experiment Station.	State College	H. P. Armsby, Ph. D	1	4
Rhode Island	Rhode Island State Agricultural Experiment Station	Kingston	C. O. Flagg, B. S	1	4
South Carolina	South Carolina Agricultural Experiment Station	Columbia	J. M. McBryde, Ph. D., LL. D	1	4
South Dakota	South Dakota Agricultural Experiment Station	Brookings	L. McLouth, Ph. D	*k*1	7
Tennessee	Tennessee Agricultural Experiment Station	Knoxville	C. W. Dabney, jr., Ph. D	1	*l*5
Texas	Texas Agricultural Experiment Station	College Station	F. A. Gulley, M. S	1	2
Utah	Agricultural Experiment Station of Utah	Logan City	J. W. Sanborn, B. S	*b*0	*b*0
Vermont	Vermont State Agricultural Experiment Station	Burlington	W. W. Cooke, M. A	1	4
Virginia	Virginia Agricultural Experiment Station	Blacksburgh	W. B. Preston	0	2
West Virginia	West Virginia Agricultural Experiment Station	Morgantown	J. A. Myers, Ph. D	1	4
Wisconsin	Agricultural Experiment Station of the University of Wisconsin.	Madison	W. A. Henry, B. Agr	1	4
				45	237

a Assistant director in charge.
b Station organized in 1889.
c Published biennially, in parts, two of which, for 1888–1889, have been issued.
d Published in two parts. Both for 1888 and one for 1889 have been issued.
e Report and three bulletins published by Station at Athens.
f Chairman of the Council.
g Does not include the annual report, which is entitled Bulletin 21.
h Entitled Bulletin 22.
i Includes one special bulletin—"facts about the Station for distribution at the agricultural fairs of 1889."
j Includes twelve meteorological bulletins.
k To June 30, 1889.
l Includes two special bulletins.

Table showing the total number of members in the working staffs of experiment stations in the United States and the number of such officers devoted to different specialties.

NOTE.—A capital letter signifies that one of the number which it follows represents an officer, who, having two titles and belonging by his first title in the column for which the letter stands, has already been entered there. Thus the entry 1 E under entomologists and opposite Florida means that one officer is known as "botanist and entomologist," and has been entered already by his first title in the E or botanists column. Two letters indicate that two of the preceding number have been entered elsewhere.

Station.	Number in staff.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
		Directors.	Chemists.	Agriculturists.	Horticulturists.	Botanists.	Entomologists.	Veterinarians.	Clerks.	In charge of substations.	Secretaries and treasurers.	Meteorologists.	Biologists.	Viticulturists.	Physicists.	Geologists.	Mycologists.	Irrigation Engineer.	Miscellaneous.
Alabama (College)	14	1	4	3		2				3		1 E	1						
Alabama (Canebrake)	3	2		2 A															
Arizona	1	1		1 A															
Arkansas	9	1	3 A	2	1		1	1					1						
California	17	1		1						*a* 6				5					*b* 4
Colorado	12	1	2	2	2 E	1		1		2	1	1						1 K	
Connecticut (State)	9	2	5 AA						1								1		*c* 2
Connecticut (Storrs)	5	2	3 A	2 A															
Delaware	5	1	2 A		1	1	1 D					1							
Florida	7	1	2		1 A	1	1 E			3									
Georgia	8	1	2	1	1		1					1				1			
Illinois	9	1	2	2	2	1 D		1			1								
Indiana	9	1	2	1	1	2	1	1											
Iowa	9	1	2	1	2 A	1	1	1			1								
Kansas	12	1	2	2	1	2	2 D	1											*d* 2
Kentucky	6	1	3 A	1	1	1 F	1												
Louisiana (Sugar)	7	2	5 A	1															
Louisiana (State)	5	2	1	1									1						
Louisiana (North Louisiana)	3	2	1 A	1															
Maine	10	1	3 A	1		2	2 EE	1	1			1							*e* 1
Maryland	7	1	1	2 A	1				1		1								*f* 1
Massachusetts (Hatch)	7	1		1	3		1					1							
Massachusetts (State)	10	1	7 A	2													1		
Michigan	21	1	4	3	4	2	3	2	1		1								
Minnesota	7	1	1	2 A	1	1 F	1	1	1										
Mississippi	9	2	2	2	1			1				1							
Missouri	10	1	2	3 A	1		1 D	2			2								
Nebraska	10	1	2	2		1	1				1				2	1 A			
Nevada	7	2	1	1	1 C	1 F	1		1										*g* 1
New Hampshire	8	1	2	3 A		1			1			1							

New Jersey (College)	6	1			1	1D	1		1				1			1			
New Jersey (State)	7	1	3						1										h2
New Mexico	1	1																	
New York (Cornell)	13	1	2	1A	2	2	2	2			2								
New York (State)	8	2	3A	1	2				1										
North Carolina	9	1	5A	1		1					1	1							
Ohio	5	2		2A	1A	1F	1	1											
Oregon	3	1	1	1A	1E	1													
Pennsylvania	13	3	6AA	3	1	1			1										
Rhode Island	5	1	1	1	1														i1
South Carolina	13	2	4	4A		1	1E	1			1		1						
South Dakota	12	1	1	2	2		2	1	2										j1
Tennessee	7	2	2A	2A	1E	1	1												h1
Texas	10	1	4	2	1			1				1B							h1
Utah	1	1																	
Vermont	8	1	3	2A	1		1		1										
Virginia	5	1	1	2A		1	1E				1								
West Virginia	4	1	2A	1					1										
Wisconsin	7	1	2	2A	1				1						1				
Office of Experiment Stations	9																		
Totals	402	63	106	73	40	30	29	19	16	14	13	10	5	5	3	3	2	1	17

a Three patrons, and three foremen of substations.
b Two superintendents of grounds or buildings, one inspector of stations, and one foreman of cellar.
c One assistant and one superintendent of grounds and buildings.
g Superintendent of mechanical department.
h Assistant.
d One foreman of farm and one foreman of gardens.
e Foreman of farm.
f Machinist.
i Apiarist.
j Herdsman

Table showing the lines of work

	Stations.	METEOROLOGY AND CLIMATOLOGY.	SOIL.			FERTILIZERS.			CROPS.				FEEDING STUFFS.		SILOS AND SILAGE.	FEEDING OF ANIMALS.				
			Geology, physics, and chemistry.	Tillage, drainage, and irrigation.	Soil tests.	Analyses.	Fertilizer inspection.*	Field experiments.	Composition.	Manuring and cultivation.	Varieties.	Rotation.	Composition.	Digestibility.		For milk.	For beef.	For mutton.	For pork.	Methods.
1	Alabama (College)	×	×			×		×		×			×							
2	Alabama (Canebrake)	×		×				×		×	×									×
3	Arkansas	×		×		×		×		×	×		×				×			
4	California		×	×																
5	Colorado	×	×	×	×	×			×	×	×		×	×						
6	Connecticut (State)		×			×	×	×	×	×			×							
7	Connecticut (Storrs)	×	×	×	×			×	×	×			×							
8	Delaware	×			×								×							
9	Florida					×		×		×						×				
10	Georgia	×	×					×	×				×							
11	Illinois	×	×			×		×	×	×	×	×			×	×	×		×	
12	Indiana	×	×	×	×	×		×		×	×	×	×			×				×
13	Iowa		×	×				×		×	×	×					×			
14	Kansas	×								×	×				×				×	
15	Kentucky					×		×		×	×								×	
16	Louisiana (Sugar)	×		×				×		×	×									
17	Louisiana (State)	×				×	×	×		×	×		×							
18	North Louisiana	×			×			×		×										
19	Maine					×	×	×			×		×	×						
20	Maryland	×						×		×	×	×			×					
21	Massachusetts (State)	×				×	×	×	×	×		×	×		×	×			×	
22	Massachusetts (Hatch)							×												
23	Michigan	×	×	×	×	×		×		×	×	×	×	×	×		×	×	×	×
24	Minnesota		×						×	×	×				×	×	×			
25	Mississippi	×		×		×	×	×	×	×		×	×		×	×	×			
26	Missouri	×		×				×	×	×	×				×	×	×			
27	Nebraska	×	×	×						×	×									
28	Nevada	×	×								×									
29	New Hampshire				×	×		×	×	×	×	×	×		×	×	×		×	
30	New Jersey (State)		×			×	×	×	×	×	×	×	×		×	×				×
31	New Jersey (College)																			
32	New York (State)	×	×	×		×		×	×	×		×	×	×	×	×		×		
33	New York (Cornell)					×				×			×		×	×		×	×	×
34	North Carolina	×	×			×	×	×	×	×		×	×							×
35	Ohio				×			×		×	×				×					×
36	Oregon		×								×		×	×						
37	Pennsylvania	×	×			×	×	×		×	×		×	×	×	×				
38	Rhode Island																			
39	South Carolina	×	×		×	×		×	×	×	×		×							
40	South Dakota	×	×							×	×									
41	Tennessee					×	×		×	×	×		×		×	×	×		×	
42	Texas	×	×	×		×		×	×	×	×		×		×	×	×		×	×
43	Vermont					×	×	×		×	×		×			×				
44	Virginia							×												
45	West Virginia																			
46	Wisconsin	×	×	×		×			×				×		×	×	×	×	×	
	Total	27	22	15	9	24	10	31	17	34	27	11	25	6	17	16	11	4	10	8

*The stations indicated in this column either officially inspect fertilizers or make analyses necessary to an inspection.

pursued at the several stations.

DAIRYING.				CHEMISTRY.—Methods of analysis.	BOTANY.				HORTICULTURE.			FORESTRY.	ENTOMOLOGY.	VETERINARY SCIENCE AND PRACTICE.				APICULTURE.	AVICULTURE.	TECHNOLOGY.—Sugar.	
Chemistry of milk.	Bacteria of milk.	Creaming of milk.	Butter making and creameries.		Systematic and physiological.	Mycology.	Seeds.	Weeds.	Vegetables.	Small fruits.	Orchard fruits and grapes.			General.	Hog cholera.	Texas fever.	Dehorning.				
		×		×	×	×		×	×	×	×	×	×								1
									×		×										2
				×		×			×	×	×		×	×		×	×			×	3
				×			×		×	×	×	×									4
				×	×	×	×	×	×	×	×		×	×			×	×			5
×				×		×	×														6
	×			×	×																7
×						×	×						×								8
					×			×			×		×								9
				×				×					×								10
				×		×		×	×	×	×	×									11
×				×	×	×		×	×	×	×		×	×							12
×			×	×		×	×		×	×	×		×	×						×	13
				×				×	×	×	×										14
				×									×								15
																				×	16
				×						×	×										17
																			×		18
				×		×	×		×				×						×		19
				×					×	×	×										20
×		×		×	×	×			×												21
						×			×	×	×		×	×							22
			×	×	×	×	×		×	×	×	×	×	×				×			23
			×		×	×			×	×	×		×	×							24
				×				×	×	×	×	×		×			×			×	25
				×			×		×	×	×		×	×							26
					×	×			×				×	×	×	×				×	27
				×					×	×	×	×									28
×		×	×	×																	29
				×		×		×	×				×							×	30
																					31
×			×	×	×	×			×	×	×	×	×						×		32
			×	×	×	×	×		×	×			×					×			33
×				×		×	×	×	×	×	×		×								34
						×			×	×	×		×	×							35
						×	×			×	×		×								36
				×			×	×	×	×	×	×									37
									×	×	×							×			38
				×		×	×						×		×						39
							×		×	×	×	×	×								40
×				×	×	×	×	×	×	×	×		×				×				41
			×	×	×	×			×	×	×		×	×		×	×				42
×			×	×					×	×	×										43
				×					×	×	×										44
×		×	×	×																	45
×		×	×	×				×	×	×	×						×				46
12	1	5	10	33	13	23	15	13	32	29	30	9	25	12	2	3	6	4	3	6	

LINES OF WORK PURSUED AT THE STATIONS.

In the foregoing table an attempt has been made to classify the lines of work pursued at the stations in a convenient manner, to show, as far as practicable, the scientific aspects of the work in connection with its economic application. A general survey of this table will show that our stations are conducting a wide range of scientific research in the laboratory and greenhouse, and an equally large amount of practical experiments in the field, the orchard, the stable, and the dairy. Twenty-seven stations are studying problems relating to meteorology and climatic conditions. Thirty-one stations are at work upon the soil, investigating its geology, physics, or chemistry, or making experiments in tillage, drainage, or irrigation, or conducting soil tests with fertilizers, or in other ways. Thirty-five stations are making analyses of commercial and home-made fertilizers, or are conducting field experiments with fertilizers. At least ten stations either exercise a fertilizer control in their respective States or make analyses on which the control is based. Thirty-nine stations are studying the more important crops either with regard to their composition, nutritive value, methods of manuring and cultivation, and the best varieties adapted to individual localities, or with reference to systems of rotation. Twenty-five stations are investigating the composition of feeding stuffs, and in some instances making digestion experiments. Seventeen stations are dealing with questions relating to silos and silage. Twenty-four stations are conducting feeding experiments for milk, beef, mutton, or pork, or are studying different methods of feeding. Eighteen stations are investigating subjects relating to dairying, including the chemistry of milk, creaming, butter making, or the construction and management of creameries. At least thirty-three stations are studying methods of analysis and other chemical work. Botanical studies occupy more or less of the attention of thirty-three stations; these include investigations in systematic and physiological botany, mycology, with especial reference to the diseases of plants, testing of seeds with reference to their vitality and purity, classification of weeds and methods for their eradication. Thirty-five stations work to a greater or less extent in horticulture, testing varieties of vegetables and large and small fruits, and making studies in varietal improvement and synonymy. Nine stations have begun operations in forestry. Twenty-five stations investigate injurious insects with a view to their restriction or destruction. Fifteen stations study and treat animal diseases, or perform such operations as dehorning of animals. At least four stations are engaged in bee culture, and three in the raising of poultry. Sugar making is experimented with at six stations, but the Louisiana Sugar Experiment Station does far more in this direction than any other.

In collecting data for this table the publications of the stations for 1888 and 1889 have been chiefly used, though in some instances these have been supplemented by special reports and other information received by this Office. Inasmuch as there has not been opportunity to verify the table by correspondence with the stations, it should be considered as only an approximately correct exhibit of the way in which the work of research in agriculture is distributed among the stations.

LIST OF AGRICULTURAL SCHOOLS AND COLLEGES IN THE UNITED STATES.

ALABAMA.—*Auburn:* Agricultural and Mechanical College, Alabama Polytechnic Institute; president, William LeRoy Broun, M. A., LL. D. *Abbeville:* Southeast Alabama Agricultural School; principal, J. S. Espy, B. S. *Athens:* North Alabama Agricultural School; principal, C. L. Newman, B. S.

ARIZONA.—*Tucson:* College of Agriculture of the University of Arizona; president, Merrill P. Freeman.

ARKANSAS.—*Fayetteville:* Arkansas Industrial University; president, Edward Hunter Murfee, M. A., LL. D.

CALIFORNIA.—*Berkeley:* College of Agriculture of the University of California; president, Horace Davis, LL. D.; Dean, Irving Stringham, Ph. D.

COLORADO.—*Fort Collins:* State Agricultural College of Colorado; president, Charles L. Ingersoll, M. S.

CONNECTICUT.—*Mansfield* (post-office, *Storrs*): Storrs Agricultural School; principal, B. F. Koons, M. A., Ph. D. *New Haven:* Sheffield Scientific School; president, Timothy Dwight, D. D., LL. D.; director, George J. Brush, LL. D.

DELAWARE.—*Newark:* Delaware College; president, Albert N. Raub, M. A., Ph. D.

FLORIDA.—*Lake City:* Florida State Agricultural and Mechanical College; president, Frank L. Kern, M. A.

GEORGIA.—*Athens:* Georgia State College of Agriculture and Mechanic Arts, of the University of Georgia; chancellor, William E. Boggs, D. D. *Cuthbert:* Southwest Georgia Agricultural College; president, Benjamin T. Hunter, M. A. *Dahlonega:* North Georgia Agricultural College; president, William S. Basinger, M. A. *Milledgeville:* Middle Georgia Millitary and Agricultural College; president, J. Colton Lynes, Ph. D. *Thomasville:* South Georgia Agricultural College; president, G. M. Lovejoy.

ILLINOIS.—*Urbana:* College of Agriculture of the University of Illinois; regent, Selim H. Peabody, Ph. D., LL. D.; dean, George E. Morrow, M. A.

INDIANA.—*Lafayette:* The School of Agriculture, Horticulture and Veterinary Science, of Purdue University; president, James H. Smart, LL. D.

IOWA.—*Ames:* Iowa State College of Agriculture and Mechanic Arts; president, W. I. Chamberlain, LL.D.

KANSAS.—*Manhattan:* Kansas State Agricultural College; president, George T. Fairchild, M. A.

KENTUCKY.—*Lexington:* Agricultural and Mechanical College of Kentucky; president, James K. Patterson, Ph. D.

LOUISIANA.—*Baton Rouge:* Louisiana State University and Agricultural and Mechanical College; president, J. W. Nicholson, M. A.

MAINE.—*Orono:* Maine State College of Agriculture and the Mechanic Arts; president, Merritt C. Fernald, M. A., Ph. D.

MARYLAND.—*Agricultural College:* Maryland Agricultural College; president, Henry E. Alvord, C. E.

MASSACHUSETTS.—*Amherst:* Massachusetts Agricultural College; president, Henry H. Goodell, M. A. *Jamaica Plain:* Bussey Institution of Harvard University; president, Charles W. Elliott, LL. D.; Dean, F. H. Storer, B. S., M. A.

MICHIGAN.—*Agricultural College:* Michigan Agricultural College; president, Oscar Clute, M. S.

MINNESOTA.—*St. Anthony Park:* College of Agriculture of the University of Minnesota; president, Cyrus Northrop, LL. D. State School of Agriculture of the University of Minnesota; principal, W. W. Pendergast.

MISSISSIPPI.—*Agricultural College:* Agricultural and Mechanical College of Mississippi; president, S. D. Lee. *Rodney:* Alcorn Agricultural and Mechanical College; president, John H. Burrus, M. A.

MISSOURI.—*Columbia:* Agricultural and Mechanical School of the University of the State of Missouri; chairman of Faculty, M. M. Fisler, D. D.

NEBRASKA.—*Lincoln:* Industrial College of the University of Nebraska; acting chancellor, Charles E. Bessey, Ph. D.

NEVADA.—*Reno:* School of Agriculture of the Nevada State University; president, Stephen A. Jones, M. A., Ph. D.

NEW HAMPSHIRE.—*Hanover:* New Hampshire College of Agriculture and the Mechanic Arts (in connection with Dartmouth College); president, Samuel C. Bartlett, D. D., LL. D.; Dean, Charles H. Pettee, M. A., C. E.

NEW JERSEY.—*New Brunswick:* Rutgers Scientific School of Rutgers College; president, Merrill Edward Gates, Ph. D., LL. D., L. H. D.

NEW MEXICO.—*Las Cruces:* Agricultural College of New Mexico; president, Hiram Hadley, M. A.

NEW YORK.—*Ithaca:* College of Agriculture of Cornell University; president, Charles Kendall Adams, LL. D.

NORTH CAROLINA.—*Raleigh:* North Carolina College of Agriculture and Mechanic Arts; president, Alexander Q. Holladay.

OHIO.—*Columbus:* Ohio State University; president, William H. Scott, LL. D.

OREGON.—*Corvallis:* Oregon State Agricultural College; president, B. L. Arnold, M. A.

PENNSYLVANIA.—*State College:* Pennsylvania State College; president, George W. Atherton, LL. D.

RHODE ISLAND.—*Kingston:* Rhode Island State Agricultural School; principal, John H. Washburn, Ph. D. *Providence:* Agricultural and Scientific Department of Brown University; president, Rev. Elisha Benjamin Andrews, D. D., LL. D.

SOUTH CAROLINA.—*Columbia:* College of Agriculture and Mechanic Arts of the University of South Carolina; president, John M. McBryde, Ph. D., LL. D. *Orangeburg:* Claflin University, College of Agriculture and Mechanics' Institute; president, L. M. Dunton, D. D.

SOUTH DAKOTA.—*Brookings:* South Dakota Agricultural College; president, Lewis McLouth, M. A., Ph. D.

TENNESSEE.—*Knoxville:* State Agricultural and Mechanical College of the University of Tennessee; president, Charles W. Dabney, jr., Ph. D., LL. D.; dean, Thomas W. Jordan, M. A.

TEXAS.—*College Station:* Agricultural and Mechanical College of Texas; chairman of College Faculty, Louis L. McInnis, M. A.

UTAH.—*Logan City:* Utah Agricultural College; president, Governor A. L. Thomas.

VERMONT.—*Burlington:* University of Vermont and State Agricultural College; president, Matthew H. Buckham, D. D.

VIRGINIA.—*Blacksburg:* Virginia Agricultural and Mechanical College; president, L. L. Lomax. *Hampton:* Hampton Normal and Agricultural Institute; president, Samuel C. Armstrong, LL. D.

WEST VIRGINIA.—*Morgantown:* West Virginia University; president, E. M. Turner, LL. D.

WISCONSIN.—*Madison:* College of Agriculture of the University of Wisconsin; president, T. C. Chamberlin, Ph. D., LL. D.

AGRICULTURAL COLLEGES RECENTLY ORGANIZED.

In accordance with a recent act of the legislature of North Carolina an independent institution, called the North Carolina College of Agriculture and the Mechanic Arts, has been organized at Raleigh and Alexander Q. Holladay elected president. The agricultural course of the University of North Carolina has been discontinued.

The Agricultural College of New Mexico was established by an act of the legislature of the Territory during the session of 1888-89. The institution has been located at Las Cruces and Hiram Hadley, M. A., elected president. A college building is being erected.

The Agricultural College of Utah was established by an act of the legislature of the Territory approved March 8, 1888, $25,000 being appropriated for the purpose. The institution has been located at Logan City. Governor A. L. Thomas is president and J. T. Hammond superintendent. A college building is being erected.

The University of Arizona was established by an act of the legislature of the Territory passed during the session of 1888-89. It is located near Tucson and Royal A. Johnson has been elected chancellor.

FARMERS' INSTITUTES.

From reports received at this Office during 1889 has been compiled the following list of States in which institutes are held, with the names and addresses of State officers and others from whom information regarding the institutes may be obtained.

ALABAMA.—Institutes are held under the direction of the State Commissioner of Agriculture, in accordance with an act of the legislature approved February 28, 1889. Address R. F. Kolb, Commissioner of Agriculture, Montgomery, Ala.

COLORADO.—Institutes are held under the direction of the State Board of Agriculture.

Address F. J. Annis, secretary State Board of Agriculture, Fort Collins, Colo.

CONNECTICUT.—The annual convention of the State Board of Agriculture is in fact a Farmers' Institute. Other meetings are held under the auspices of the board in different parts of the State.

Address T. S. Gold, secretary State Board of Agriculture, West Cornwall, Conn.

DELAWARE.—Institutes are held in the several counties with the aid of appropriations by the legislature.

Address Dr. J. J. Black, New Castle, New Castle County; J. A. Fulton, Dover, Kent County; C. C. Stockley, Georgetown, Sussex County.

ILLINOIS.—Institutes are held by the State Board of Agriculture, county agricultural societies, and other local organizations.

Address W. C. Garrow, secretary State Board of Agriculture, Springfield, Ill.

INDIANA.—By an act of the legislature approved March 9, 1889, institutes are held under the direction of the trustees and faculty of Purdue University.

Address W. C. Latta, M. S., superintendent of Farmers' Institutes, Purdue University, Lafayette, Ind.

IOWA.—Institutes are held under the direction of a voluntary organization termed the Iowa Association of Agricultural and Industrial Instruction.

Address George VanHouten, Secretary Iowa Association of Agricultural and Industrial Instruction, Lenox, Iowa.

KENTUCKY.—Institutes are held by a voluntary organization known as the Kentucky Farmers' Institute, of which J. D. Clardy, of Newstead, is president.

Address C. Y. Wilson, Commissioner of Agriculture, Frankfort, Ky.

MASSACHUSETTS.—Institutes are held under the direction of the State Board of Agriculture, co-operating with agricultural societies and farmers' clubs.

Address W. R. Sessions, secretary Massachusetts State Board of Agriculture, Boston, Mass.

MICHIGAN.—Institutes are held under the direction of the State Board of Agriculture.

Address Henry G. Reynolds, secretary State Board of Agriculture, Agricultural College Post-office, Mich.

MINNESOTA.—Institutes are held under the direction of a board of administration, consisting of two regents of the University of Minnesota, and the presidents of the Farmers' Alliance, State Agricultural Society, State Horticultural Society and State Dairymen's Association.

Address O. C. Gregg, superintendent of Farmers' Institutes, 1425 Sixth street, southeast, Minneapolis, Minn.

MISSOURI.—Institutes are held under the direction of the State Board of Agriculture.

Address Levi Chubbuck, secretary State Board of Agriculture, Columbia, Mo.

NEW HAMPSHIRE.—Institutes are held under the direction of the State Board of Agriculture.

Address N. J. Bachelder, secretary State Board of Agriculture, Concord, N. H.

NEW JERSEY.—Institutes are held under the direction of the executive committee of the State Board of Agriculture and by county boards of agriculture.

Address Franklin Dye, secretary State Board of Agriculture, Trenton, N. J.

NEW YORK.—Institutes are held under the direction of the State Agricultural Society.

Address J. S. Woodward, secretary State Agricultural Society, Albany, N. Y.

NORTH CAROLINA.—Institutes are held under the direction of the State Board of Agriculture.

Address John Robinson, Commissioner of Agriculture, Raleigh, N. C.

OHIO.—Institutes are held under the direction of the State Board of Agriculture, through its secretary.

Address L. M. Bonham, secretary State Board of Agriculture, Columbus, Ohio.

OREGON.—Institutes are held under the direction of the Board of Regents of the State Agricultural College.

Address E. Grimm, B. S., director Oregon Agricultural Experiment Station, Corvallis, Oregon.

PENNSYLVANIA.—Institutes are held under the direction of the State Board of Agriculture.

Address T. J. Edge, secretary State Board of Agriculture, Harrisburg, Pa.

RHODE ISLAND.—Institutes are held under the direction of the State Board of Agriculture.

Address David S. Collins, secretary State Board of Agriculture, Providence, R. I.

SOUTH CAROLINA.—Institutes are held under the direction of the State Board of Agriculture.

Address A. P. Butler, Commissioner of Agriculture, Columbia, S. C.

SOUTH DAKOTA.—Institutes are held by the State Agricultural College and Experiment Station, Farmers' Alliances and similar organizations.

Address Lewis McLouth, Ph. D., president South Dakota Agricultural College, Brookings, S. Dak.

TEXAS.—Institutes are held under the management of the board of directors of the Agricultural and Mechanical College of Texas.

Address F. A. Gulley, M. S., director Texas Agricultural Experiment Station, College Station, Tex.

VERMONT.—Institutes are held under the direction of the State Board of Agriculture, through its secretary.

Address W. W. Cooke, M. A., secretary State Board of Agriculture, Burlington, Vt.

WEST VIRGINIA.—Farmers' meetings corresponding to institutes are held under direction of the West Virginia Agricultural Experiment Station.

Address J. A. Myers, Ph. D., director West Virginia Agricultural Experiment Station, Morgantown, W. Va.

WISCONSIN.—Institutes are held under the direction of the Board of Regents of the State University.

Address W. H. Morrison, superintendent of Farmers' Institutes, Madison, Wis.

GROWTH AND STATUS OF THE EXPERIMENT STATION ENTERPRISE IN THE UNITED STATES.

Although researches in agricultural science akin to those now conducted by the experiment stations have been going on for half a century, the first regularly organized station in Europe was instituted about thirty-seven years and the first one in this country only fourteen years ago, and the majority of our stations have been in active operation for less than two years. Twenty years ago not half a dozen men in the United States were devoting themselves to special research in agricultural chemistry. The agricultural schools and colleges were then struggling for existence. To-day these institutions hold a recognized place in our system of education, and in connection with them experiment stations are in operation in thirty-nine States, and plans are being made for their establishment in two other States and three Territories.

In a paper read before the late meeting of the American Historical Association in this city Prof. G. Brown Goode, Assistant Secretary of the Smithsonian Institution, called attention to the colleges established by the so-called "land grant" or Morrill act of 1862, and to the experiment stations organized under the Hatch act of 1887, as among the most noteworthy features in the progress of American science. At the Paris Exposition, in 1889, foreign students of these subjects who examined the exhibit and report of the U. S. Department of Agriculture, expressed surprise and admiration that the United States should have evinced their faith in science and education as aids to agriculture by enterprises on such a scale.

When we consider how recently our older colleges and universities have begun to make adequate provision for instruction in the natural sciences and how few of them are engaged in original research, this advance in agricultural science is certainly remarkable; and if the early results are crude and the fruit immature, there is good ground to hope that, with the progress of time and increase of experience, the product will be of a higher and higher grade.

One of the noteworthy features of the experiment station enterprise in this country is the comprehensiveness of the act of Congress under which the stations are now operating. The full significance

of this measure will undoubtedly become more and more apparent as time goes on. Even now the effects of certain of its provisions can be much more clearly seen than a year ago. Under this act it is the duty of the stations, as departments of the "land-grant" colleges, both to conduct investigations for the benefit of agriculture and to diffuse useful information among farmers by frequent and numerous publications.

A first effect of their union with the colleges has been to secure for the stations much better facilities for their work than they could otherwise have obtained; for, following out the spirit of this act, especially as indicated in the report of the committee of the House of Representatives on the Hatch bill,* the colleges have placed at the disposal of the stations, buildings, laboratories, farms, apparatus and books, and have thus enabled the stations in many cases to enter at once upon effective work. In some instances, moreover, these colleges had already carried on a large amount of successful experimental work in agriculture, of which the stations were enabled to reap the fruits. The aid offered by the colleges has also been of such a character as to point out to some of the stations lines in which they could most successfully work, at least for the present, and to give a scientific quality and accuracy to their work which otherwise it could not have attained in so short a period. Without doubt the colleges have received a full share of benefit in return, for besides the most valuable intellectual quickening which comes to any educational institution from original research in its midst, there have been additions of students and of resources to these colleges, due to the openings for young men as workers in agricultural science, which the stations offer, to the increased interest in these matters among farmers, and to the general advertisement which the colleges have received through the wide-spread station publications.

On the other hand, their connection with the colleges has not prevented, but has rather helped the station workers to come into direct personal contact with the farmers. In many of the States members of the station staffs have been either organizers of farmers' institutes or among the foremost workers in them. The calls upon the station officers to address agricultural societies, granges, and other organizations of farmers, have already been very numerous, and are constantly increasing; and the very large correspondence which the stations are carrying on in response to inquiries from farmers on almost every topic connected with farm theory and practice have tended to keep the stations on the alert to understand the needs of the toilers on the farms, and as far as possible to give them helpful information. And here again the reaction upon the colleges has been valuable.

Moreover the results worked out in the laboratories and the experimental fields of the stations have in many instances been verified, enlarged, and applied to practice by farmers on their own farms. Extensive experiments have been carried on by considerable numbers of farmers on plans formulated by the stations. In fact, the college, the station, and the farmer are working together and to the advantage of all concerned.

A second provision of the act of Congress under which the stations are organized relates to the publication of results of their investigations for the benefit of farmers. This important task was not left to

* See Experiment Station Bulletin No. 1 of this Office, in which this report and the United States legislation upon the subject are stated.

be fulfilled by casual addresses at farmers' meetings and talks with visitors at the stations, but provision was expressly made for the issuing of annual reports and bulletins or "reports of progress." The latter the stations are required by law to publish at least quarterly. During 1889 some two hundred and eighty reports and bulletins have been published by the stations. The number of printed pages contained in single copies of these documents aggregated about 10,000. At a low estimate, 3,000 copies of each of these publications have been distributed, making a total of 30,000,000 of pages containing information on agricultural topics disseminated among the people by the stations during the past year. Furthermore, results and to some extent the processes of experiments are described in thousands of newspapers and other periodicals. The information which the stations have had to give is thus spread widely throughout the country. It is believed that no other arrangement for popularizing the teachings of scientific research has yet been devised which, in scope and far-reaching effectiveness, equals this scheme for the diffusion of agricultural science. The wisest educators in our great universities are constantly deploring the lack of means for the wide publication of the results of their studies and investigations, which are thus a long time in reaching the average citizen for whose benefit they are really intended. But here is a way by which farmers may and do receive the latest results of researches in agricultural science almost as soon as the investigations are concluded.

Another encouraging fact is the financial and moral support given the stations by the State legislatures, local communities, agricultural associations, and private individuals. The appropriations by the State legislatures for the past year amount to about $125,000. The other gifts of land, buildings, equipment, and money are quite considerable. This indicates that the generous policy pursued by the General Government acts as a proper stimulus to individual activity, opens the purses of the communities in which the stations are working, and leads to the building of large and strong institutions on the foundations laid by Congress; that is, the same results will follow in the case of the stations as have been experienced with the land-grant colleges, whose endowments, buildings, and equipments have been enlarged by State appropriations and private munificence until they are now worth more than double the sum obtained by the sale of public lands awarded them in 1862, while they are annually receiving more from the same sources.

The present status of the stations may be briefly described as follows: There are about fifty stations in thirty-nine States. They employ almost exactly four hundred trained specialists and other workers, and are conducting a large amount of scientific research in the laboratory and the greenhouse, and of practical experimenting in the field, the orchard, the stable, and the dairy. Some of the stations confine themselves to a few narrow lines of inquiry, as feeding of animals, analyses of fertilizers and fodders, and irrigation or sugar making, but most of them give attention to several branches of work. Co-operation with the agricultural colleges has put the stations on a strong foundation, given them fair equipments, and helped them to begin their work with a measure of thoroughness and accuracy. In most of the States the stations have already done work of such evident practical usefulness as to secure the cordial support of the legislatures, the public, and the press. The mailing lists of the

stations aggregate about two hundred thousand names, and the chief results of their work are published in thousands of newspapers and other periodicals. It is safe to say, therefore, that millions of our agricultural population have already received, and are constantly receiving, useful information on topics directly connected with their daily occupation. In New York State alone the Station authorities estimate that six hundred thousand farmers are regularly informed of the operations of the stations in that State. In short, the stations are working with a high purpose, are getting valuable results, are supported in their efforts by the government and the people, and are bringing practical information home to large masses of the farmers.

DIFFICULTIES AND DANGERS—PROMISE OF SUCCESS OF THE EXPERIMENT STATION ENTERPRISE.

The organization of the experiment station enterprise on so large a scale could hardly be without perplexing difficulties and grave dangers. For a considerable time much of the work of the stations must be comparatively crude and the results unsatisfactory.

The difficulties which the experiment stations meet are those common to our educational and scientific institutions generally, and belong mainly to three categories—political complications, inexperience, and superficiality.

Some of the stations have suffered more or less seriously from political influences, but fortunately the number is not large. The disadvantages of the second sort appear in the inexperience of the managers of the stations, the popular and indeed natural impression that experimenting for farmers can be best done by farmers on the farm, the lack of trained specialists, and the lack of information as to what has been done. The evil of superficiality manifests itself in the undertaking of too many lines of investigation; the attempt to grapple with broad and complex rather than narrow and specific problems; and the lack of the accurate, thorough, and profound research by which alone the laws that underlie the right practice of farming can be discovered. These difficulties will pass away in proportion as the higher education and science are cultivated in this country, as station managers and experimenters gain experience, and the people learn what can be rightly expected and demanded of the stations.

Some of the reasons for anticipating large success from the work of the stations have been already touched upon. The trend of public feeling is strongly opposed to what is popularly called "politics" in their management. The stations are connected with the best colleges and universities of the country and have the cordial sympathy of the people. The lack of experience on the part of the managers is an evil which time will mend. Numbers of young men—able, scholarly, earnest, and enthusiastic—inspired by the promise of usefulness and success, are availing themselves of the training of the best schools and laboratories in this country and in Europe, and will be ready to do the work of specialists which the stations so sorely need. The farmers will find with us, as they have in Europe, and by the same costly experience, that what they want is best got by the most skillful specialists working in the laboratory, the greenhouse, and the experimental stable. The keen criticism of men of science and of the press, as well as the experience within the stations, will lead to more thorough and scientific research, and it is hoped that the

influence of this Department in the fulfillment of the duty imposed upon it by Congress may help to proper co-ordination of the work of the stations, while it brings them the fruits of research in other parts of the world and collates their products and gives the results to those who need them and will use them.

Indeed, there are most hopeful indications that these improvements are gradually and surely coming to pass.

One of these is the evident desire on the part of the station workers to do their work thoroughly and well. This is manifested in their publications and in their correspondence with this Office, and was brought out very clearly at the recent meeting of the Association of American Agricultural Colleges and Experiment Stations at Washington. At this convention the delegates were impatient of discussions which related merely to the details of the organization of the stations, and grew enthusiastic when the methods and results of investigation were debated. A division of the association into sections was made for the express purpose of enabling workers in particular lines to confer more intimately and deliberate more deeply concerning matters vitally connected with the successful progress of their work in the several departments.

Another very hopeful indication is the desire among the stations for co-operation. This desire has been manifested in many ways, but most publicly at the meetings of station officers at Washington, D. C., and Columbus, Ohio, for consultation regarding co-operative work in soil testing and in horticulture. These things show how earnest the station men are to take advantage of the information they can get from any and every source and to expend their energies and the means at their disposal most economically and effectively.

It is also evident that the stations are coming to appreciate the importance of the abstract research which lies at the base of their most successful work. At the meetings of experiment station workers these matters are earnestly discussed. The Association of Official Agricultural Chemists is devoting itself to the systematic study of methods of chemical analysis. Steps are being taken toward a systematic inquiry into the constitution of vegetable and animal products, which will involve the most detailed and thorough research in analytical, organic, and physical chemistry. The botanists, horticulturists, and entomologists are planning scientific researches. Work in mycology and bacteriology is developing. There is every reason to believe that the fruits will be most valuable.

But, after all, the security for success is in the purpose of the workers and in the spirit of the public whom they serve and upon whose sympathy their success must ultimately depend. These all agree in the aspiration for what is best and the determination that the best shall be attained. For the success of the experiment station as of other scientific and educational enterprises this ideal is the foundation, the promise, and the hope.

INDEX.

A.

E.

F.

I.

J.

K.

L.

M.

N.

T.

U.

V.